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ABSTRACT

Low cost microcomputers with high resolution graphics provide students and educators with fast and accurate visual representations of mathematics relations and extend the benefits of discovery learning into the high school and college mathematics classroom. A recent challenge has been to use the computer in motivating students and teaching problem-solving--areas of mathematics instruction that have traditionally been weak. At Albany Junior College, this challenge has been met with the development of six computer-assisted, discovery learning trigonometry units, which supplement regular classroom instruction and are completed at the college's math lab using Apple II computers. After students are introduced to plotting trigonometric functions, BASIC computer language notation, and fundamental computer operations, they sequentially complete the: (1) Orientation and Discovery Learning Unit, focusing on gaining familiarity with the computer; (2) Exploration and Observation Unit, focusing on cause-and-effect relationships between particular parts of equations and their graphs; (3) Holistic Graphics Unit, focusing on sketching graphs from equations; (4) Problem-Solving Graphics Unit, focusing on determining equations from their graphs; (5) Identity Graphing Unit; and (6) Introduction to Polar Coordinates. Student reactions to the units have been positive. (Problem sets for each unit and samples of computer-produced graphs and instructions for selected problems are appended.) (JP)

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DISCOVERY LEARNING IN TRIGONOMETRY USING MICROCOMPUTERS*

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Two-Year Colleges, Annual Meeting (October, 1980).

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Introduction

The availability of low cost microcomputers (starting at $1000) with high resolution graphics provides st udents and educators with fast and accurate visual representations of mathematics relations. Concepts which require a high level of accuracy or extensive computation can now be effectively taught with the aid of computer graphics.

The availability of economical computer graphics also enables educators to use the pedogogical method of Discovery at higher levels (mathematics in high school and college) of learning. Discovery learning has the advantages of increased motivation, better retention and enhanced problem solving skills. One traditional disadvantage of Discovery learning is that it is slower than other methods. This weakness has restricted many lessons to basic concepts and introductory material. Another limitation of Discovery learning has been the need for an extensive number of examples for some students to understand a concept.

With the aid of computers, Discovery learning can be significantly sped up and improved. The computer can generate a sufficient number of examples in a short enough period of time to facilitate pattern recognition. A computer can also accurately present the fine detail of examples, so students are less likely to make hasty generalizations. Computers have the capacity to present examples in an uncluttered and organized format which filters out extraneous and unrelated material.

In the past educators have proven that the computer can be effectively used to do things which were already being done reasonably well without computers. An example of this is Drill and Practice programs. Drill and Practice has been effectively used by educators for years without the aid of computers. The real

challenge for the 1980's is the use of computers in areas of mathematics instruction which are traditionally weak. Two of these critical areas are motivation and problem solving. Research supports the idea that computers in mathematics instruction increases motivation (Critchfield & Dwyer 1974, Dwyer 1974, Casner 1978, DeLoatch 1978, Papert 1978, and Vincent 1978). Recent studies also indicate that the educational use of computers may enhance students' problem solving skills in other environments (Anderson 1978, Johnson and Harding 1979).

Based on this information, I designed a set of Discovery learning programs in Trigonometry for the Apple II computer which would be both motivating and challenging for both high school and college students.

Six Units for Trigonometry

The programs are meant to supplement a regular college or high school trigonometry course. Attached are actual assignments for each of the six computer units. The Apple II computers at Albany Junior College are located in the math lab and students are assigned these units outside of regular class time (similar to regular homework assignments).

Prior to the first computer assignment the class does each of the following:

a. Students receive instruction on plotting trigonometric function by the point method (plotting several points, then drawing a smooth curve connecting the points). Students gain an appreciation for the speed and accuracy of computers after plotting graphs by this method.

b. Students receive a half hour of instruction on stating functions in the BASIC computer language notation. The programs require that all functions entered into the computer

must be in this form. Appendix A of the assignment booklet provides an easy reference to BASIC notation.

c. A class demonstration of the Apple II is given to show the fundamental operation of the computer. Insertion of diskettes, turning the machine on and off, procedures for running a program, etc. are covered.

The student's first "hands on" experience with the computer is extremely important. Many students are apprehensive of computers and need a gentle introduction. The first experience should be as successful and rewarding to the student as possible. If the student has a positive attitude from the beginning, then the rest of the assignments will go smoothly and be more educationally effective.

1. Orientation and Free Discovery Unit (Assignment #1)

   This unit is deisnged to promote the feeling that the computer is a versatile tool for investigating mathematical relationships. The programs give the student many options and a great deal of control over the graphic result. The student in these lessons controls the computer, instead of the computer controlling the student. The philosophy behind the development of these programs is that the student always plays the dominant role. The computer is merely a tool which enables students to discover new concepts through graphics programs.

2. Exploration and Observation Unit (Assignment #2)

   In this unit students observe the cause and effect relationships between particular parts of equations and their graphs. Students at this stage are fine tuning their discovery skills in order to form hypothesis which can be tested through the use of the computer.

3. Holistic Graphing Unit (Assignment #3)

This assignment requires students to begin sketching graphs from given equations. The method of plotting several points is discouraged. Graphs of trigonometric functions can be thought of as pieces of string which are distorted (sometimes cut) by different aspects of their equations. The goal of this unit is to enable students to quickly visualize the graphs of equations from patterns observed during earlier assignments. The computer provides immediate feedback so students can determine the correctness of their graph.

4. Problem Solving Graphics Unit (Assignment #4)

Students use skills learned in the first three units to solve an interesting form of graphics problem. The student is given a graph and asked to figure out its equation. He is allowed as many guesses as he needs and full use of the graphics system to solve the problem. This program is designed to strengthen intuitive graphic thinking skills while developing important problem solving strategies.

5. Identity Graphing Unit (Assignment #5)

This assignment provides a visual way of interpreting and conceptualizing trigonometric identities. Students use the computer to observe the graphic transformation of one side of an identity into the graph representing the other side. For some students this confirmation of identities is more convincing than a formal proof. Non-identities are also explored in this section since negative examples are an important part of concept formulation.

6. Introduction to Polar Coordinates (Assignment #6)

This unit enables students to apply discovery skills acquired in

the previous five units to a different graphical representation of trigonometric functions.

Slides of the Screen Displays (The talk included a 35 mm slide presentation of the actual programs and graphical displays.)

Summary and Results

During the development of these programs five college trigonometry classes at Albany Junior College tested the current and earlier versions of the computer assignments. The following informal results were observed.

a. The prestige and self-image of many students improved due to their operation and control over a complex machine, the computer.

b. Bright students continued to do well in trigonometry before and after the computer assignments. Average and slower students, however, showed a definite increase in test scores and homework grades after going through the six units. This may be caused by improved motivation or from an increased understanding of trigonometry.

c. For most students these six computer units were their first "hands on" experience with a computer. Some students took subsequent computer courses or changed their major to Computer Science as a result of this experience.

d. Some students changed the type of questions they asked in class. There were fewer, "Just show me how to derive the answer.", comments and more questions of the type "What would happen if you did ..... ?".

The economical microcomputer can be effectively used to teach relatively complex topics using a Discovery approach. Students are motivated by programs which provide easy operation, high-resolution graphics, a high degree of

student control, and Discovery learning. Supplementing regular class instructions with computer assignments can be beneficial and interesting for students and teachers alike.

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"HANDS ON" COMPUTER ASSIGNMENTS

SIX UNITS FOR TRIGONOMETRY

1. Orientation and Free Discovery
2. Exploration and Observation
3. Holistic Graphing
4. Graphic Problem Solving
5. Identity Graphing
6. Introduction to Polar Coordinates

Assignment #1: Orientation and Free Discovery Unit

TRIG DEMO is a demonstration of the capabilities of the programs GENERAL TRIG and TRIG TREND. Several graphs are automatically drawn on the three available grids on the high resolution screen. This program provides an introduction to the trigonometric programs and the Apple computer.

GENERAL TRIG is an all purpose trigonometric graphing program. Functions must be entered using BASIC notation. The trigonometric functions sec, csc, and cot are not directly available. These functions must be entered in their reciprocal form of 1/COS(X), 1/SIN(X), and 1/TAN(X) respectively.

1. Run TRIG DEMO and observe the equations and their graph.
2. Graph each of the following trigonometric functions using the GENERAL TRIG program and record the results.

a.) F(X) = SIN(X)

b.) F(X) = 2*SIN(X)

c.) F(X) = 1/SIN(X)

d.) F(X) = SIN(5*X) + COS(X)

3. Graph ten different trigonometric functions using GENERAL TRIG. Become familiar with all of the available options. Record a sketch of five of the more interesting functions.

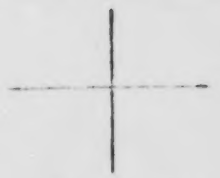
a.) F(X) = _____

b.) F(X) = _____

c.) F(X) = _____

d.) F(X) = _____

e.) F(X) = _____



4. Translate each of the following trigonometric functions into BASIC notation; then graph it using the GENERAL TRIG program.

a.) y = cos x
F(X) = _____

b.) y = 1 + sec(x)
F(X) = _____

c.) y = $\tan^2 x$
F(X) = _____

d.) y = | 3 sin x |
F(X) = _____

e.) y = x sin (x + π/2)
F(X) = _____

f.) y = $\frac{\sin x}{\csc^2 x}$
F(X) = _____

Assignment #2: Exploration and Observation Unit

TRIG TREND is a special purpose program which graphs families of functions. By including the constant "C" in the definition of the function to be graphed the computer automatically graphs the function for the values C = 1, 2, 3.

Example: Entering "F(X) = C*COS(X)" automatically graphs the three functions,

F(X) = 1*COS(X) (white graph)

F(X) = 2*COS(X) (blue graph)

F(X) = 3*COS(X) (green graph)

This program enables student to easily discover the effects of various constants on trigonometric functions.

1. For each of the following equations determine the effect the constant "C" has on the resultant graph. Use the TRIG TREND program and record the graphs below.

a.) F(X) = C*SIN(X)

b.) F(X) = C*COS(X)

c.) F(X) = C*TAN(X)

d.) F(X) = C/COS(X)

e.) F(X) = C/SIN(X)

f.) F(X) = C/TAN(X)

g.) F(X) = SIN(C*X)

h.) F(X) = SIN(C/X)

i.) F(X) = COS(C*X)

j.) F(X) = 1/COS(C*X)

k.) F(X) = SIN(X) + C

l.) F(X) = COS(X) - C

m.) F(X) = SIN(X+C)

n.) F(X) = SIN(X-C)

o.) F(X) = TAN(X+C)

p.) F(X) = COS(X-C)

q.) F(X) = SIN(X)^C

r.) F(X) = TAN(X)^C

s.) F(X) = ABS(C*SIN(X/C))

2. Using the TRIG TREND program graph several trigonometric functions containing the constant "C". Record your observations and graphs below.

a.) F(X) = _____

b.) F(X) = _____

c.) F(X) = _____

d.) F(X) = _____

e.) F(X) = _____

f.) F(X) = _____

g.) F(X) = _____

h.) F(X) = _____

3. Using the GENERAL TRIG program graph the following sets of functions on the same grid. Note the graphic effect.

a.) F(X) = SIN(X)
F(X) = -SIN(X)

b.) F(X) = COS(X)
F(X) = -COS(X)

c.) F(X) = TAN(X)
F(X) = -TAN(X)

d.) F(X) = 1/SIN(X)
F(X) = -1/SIN(X)

e.) F(X) = SIN(X)
F(X) = 1/SIN(X)

f.) F(X) = COS(X)
F(X) = 1/COS(X)

g.) F(X) = 1/SIN(X)
F(X) = 1/SIN(X)^2

h.) F(X) = TAN(X)
F(X) = TAN(X)^2

i.) F(X) = SIN(X)
F(X) = SIN(-X)

j.) F(X) = COS(X)
F(X) = COS(-X)

j.) F(X) = TAN(X)
F(X) = TAN(-X)

Assignment #3: Holistic Graphing Unit

In this unit you will sketch graphs of trigonometric equations. You are encouraged to analyze the equation and sketch the graph without plotting individual points. Take into consideration factors such as amplitude, period, phase shift and patterns you have discovered in previous computer assignments.

1. Sketch the graph of the following functions. Use the program GENERAL TRIG to check your answers.

a.) F(X) = 2*SIN(X)

b.) F(X) = -COS(X)

c.) F(X) = -3*SIN(X) + 1

d.) F(X) = SIN(X - PI/2)

e.) F(X) = 1/SIN(X*2)

f.) F(X) = 2*COS(3*X)

g.) F(X) = -4*COS(2*X)

h.) F(X) = SIN(3/4*X)

i.) F(X) = SIN(X)^2

j.) F(X) = SIN(2*X)^2

k.) F(X) = 3*TAN(X)

l.) F(X) = -TAN(X)

m.) F(X) = 1/SIN(X) + 1

n.) F(X) = 1/COS(X) + 2

o.) F(X) = COS(X-PI/2)

p.) F(X) = 1/SIN(X + PI/4)

q.) F(X) = (1/3)*COS(3*X-PI)

r.) F(X) = 5*1/COS(3*X + 3*PI/2)

Assignment #4: Problem Solving Graphics Unit

TRIG PROBLEM SOLVING is a program which requires you to use skills learned from interacting with the computer. This program randomly selects a function and plots the graph on the screen. Your problem is to correctly identify the equation of the graph. You are allowed as many guesses as you want. Points are only lost when you "give up" and let the computer answer the problem.

1. Run TRIG PROBLEM SOLVING on level 1 for at least 10 rounds, while attaining a success percentage of 80 or above.

   Math Lab Instructor's initials _____

2. Run the program on level 2 for at least 5 rounds, while attaining a success percentage of 80 or above.

   Math Lab Instructor's initials _____

3. Run the program on level 3 for at least 5 rounds, while attaining a success percentage of 60 or above.

   Math Lab Instructor's initials _____

4. Run the program on levels 4-6 for at least 8 rounds, while attaining a success percentage of 50 or above.

   Math Lab Instructor's initials _____

Assignment #5: Identity Graphing Unit

This unit is designed to provide a visual way of interpreting and conceptualizing trigonometric identities. You will use the GENERAL TRIG program to graphically show that both sides of the identity are equal.

1. Graph both sides of each of the following identities on a single grid. Graph the components of each side as listed. Use grid size #1.

   a.) Identity: $\sin^2 x + \cos^2 x = 1$

   Left side:

```
F(X) = SIN(X)^2
F(X) = COS(X)^2
F(X) = SIN(X)^2 + COS(X)^2
```

   Right side:

```
F(X) = 1
```

   b.) Identity: $\tan^2 x + 1 = \sec^2 x$

   Left side:

```
F(X) = TAN(X)
F(X) = TAN(X)^2
F(X) = TAN(X)^2 + 1
```

   Right side:

```
F(X) = 1/COS(X)^2
```

   c.) Identity: $\sin(x + \frac{\pi}{2}) = \cos x$

   Left side:

```
F(X) = SIN(X)
F(X) = SIN(X = PI/2)
```

   Right side:

```
F(X) = COS(X)
```

d.) Identity: $\sin 2x = 2 \sin x \cos x$

Right side:

```
F(X) = SIN(X)
F(X) = COS(X)
F(X) = SIN(X)*COS(X)
F(X) = 2*SIN(X)*COS(X)
```

Left side:

```
F(X) = SIN(2*X)
```

2. Break each of the following identities down into components and graphically show that they are true. Use the GENERAL TRIG program.

   a. $\cos 2x = \cos^2 x - \sin^2 x$

   b. $\cot^2 x + 1 = \csc^2 x$

   c. $\cos(\pi/2 + x) = -\sin x$

3. Using GENERAL TRIG determine which of the following equations are identities and which are not. Use grid #1.

   a.) $\sin^2 \frac{X}{2} = \frac{1 - \cos}{2}$ _____

   b.) $\cos 2x = \sin^2 - \cos^2 x$ _____

   c.) $\sin x = \sin(-x)$ _____

   d.) $\tan 2x = \frac{2 \tan x}{1 - \tan^2 x}$ _____

   e.) $1 - 2 \sin^2 x = 2 \cos^2 x - 1$ _____

   f.) $-\tan x = \cot(x + \pi/2)$ _____

   g.) $3 \tan 3x = 1/3 \sin x - 3 \cos x$ _____

Assignment #6: Introduction to Polar Graphing

GENERAL POLAR is an all purpose program for computer graphing of polar equations. This program will enable you to apply discovery and pattern recognition skills in an alternative graphing system.

1. Graph each of the following polar equations using GENERAL POLAR

a.) R(A) = 1

b.) R(A) = A

c.) R(A) = SIN(A)

d.) R(A) = COS(A)

e.) R(A) = SIN(2*A)

f.) R(A) = SIN(3*A)

g.) R(A) = COS(3*A)

h.) R(A) = SIN(4*A)

i.) R(A) = COS(A*.7)
(Set the maximum angle value to 63 radians)

j.) R(A) = 1/(2-COS(X))

2. Graph each of the following polar families and experiment with different n values (positive integers). Record a sketch of each problem and explain the effect of different n values.

a.) R(A) = n*SIN(A)

b.) R(A) = n*COS(A)

c.) R(A) = COS(n*A)
(Hint: Does it make a difference whether n is odd or even?)

d.) R(A) = (2*n)/(1-2*COS(A))

e.) R(A) = n/(2-COS(A))

f.) R(A) = SIN(4*A) + n

g.) R(A) = n + n*SIN(A)

h.) R(A) = n - n*COS(A)

i.) R(A) = n + A

j.) R(A) = TAN(n*A)

Appendix A

BASIC Math

BASIC Symbols	Meaning	BASIC Example	Algebra
+	Add	X+Y	x+y
-	Subtract	X-Y	x-y
*	Multiply	X*Y	xy
/	Divide	A/B	$\frac{a}{b}$
^	Power	A^2	a^2
RND ( )	Random Number	RND (40)	none
SQR ( )	Square Root	SQR (64)	$\sqrt{64}$
ABS ( )	Absolute Value	ABS (-55)	/-55/
SIN ( )	Sine (Radians)	SIN (x)	sin x
COS ( )	Cosine (Radians)	COS (x)	cos x
TAN ( )	Tangent (Radians)	TAN ( )	tan x
ATN ( )	Arc tangent (Radians)	ATN (1)	Arc tan 1
EXP ( )	e to a power	EXP (2)	e^2
LOG ( )	Natural Log	LOG (10)	ln 10

MATHEMATICAL GRAPHING COURSEWARE
FOR
TRIGONOMETRY
PROJECT DIRECTOR
JOHN C. KELLY, PH. D.
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PRESS ESC KEY FOR A MENU

MENU OF PROGRAMS

1. TRIG DEMO. . . . . TYPE 1
2. GENERAL TRIG. . . . . TYPE 2
3. TRIG TREND. . . . . TYPE 3
4. TRIG PROBLEM SOLVING. . . TYPE 4
5. POLAR DEMO. . . . . TYPE 5
6. GENERAL POLAR. . . . . TYPE 6
7. POLAR TREND. . . . . TYPE 7
8. QUIT. . . . . TYPE 8

SELECT A PROGRAM THEN PRESS RETURN

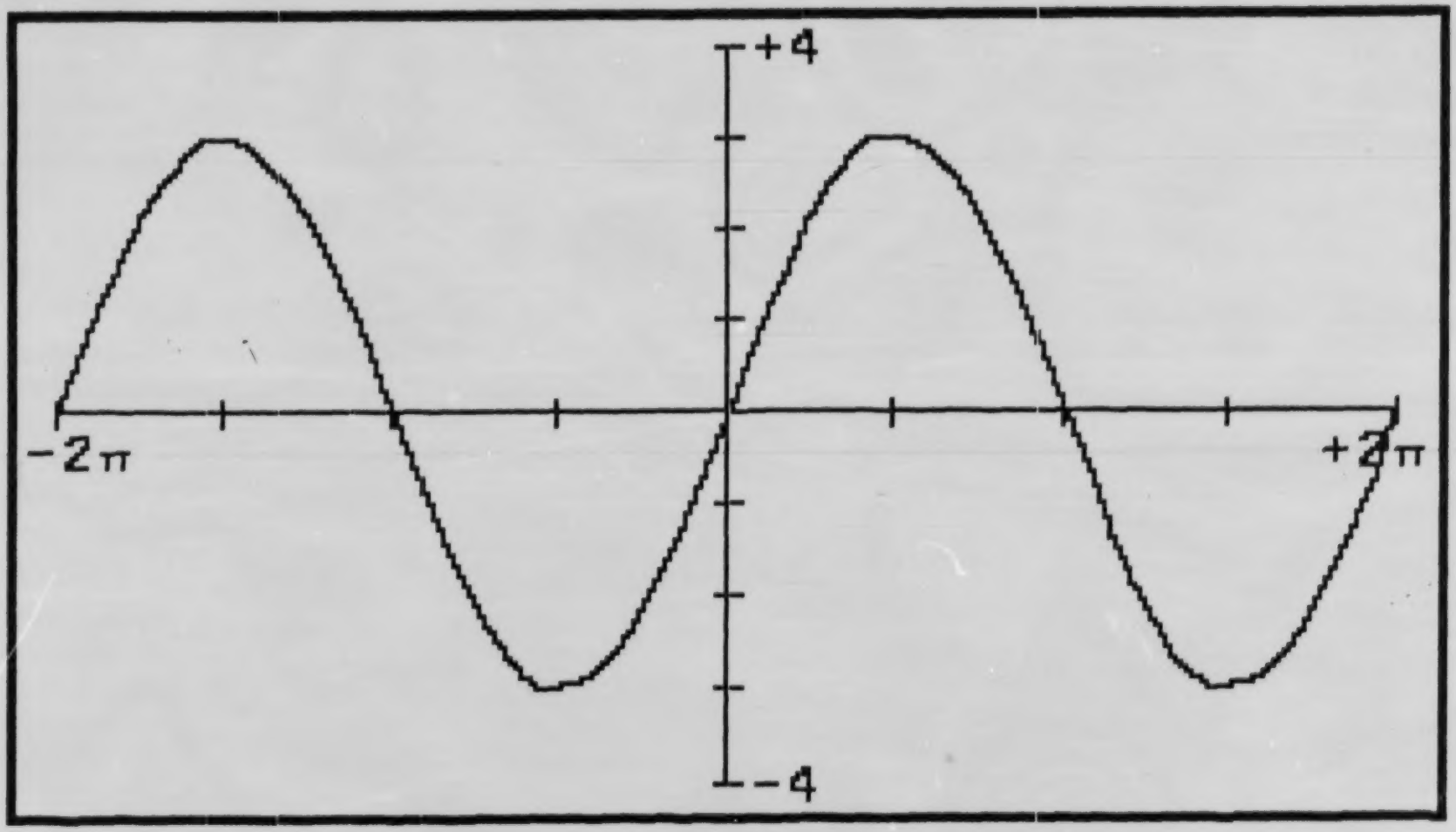
==>

TRIGONOMETRIC DEMONSTRATION PROGRAM

>>> PRESS SPACE BAR TO CONTINUE <<<

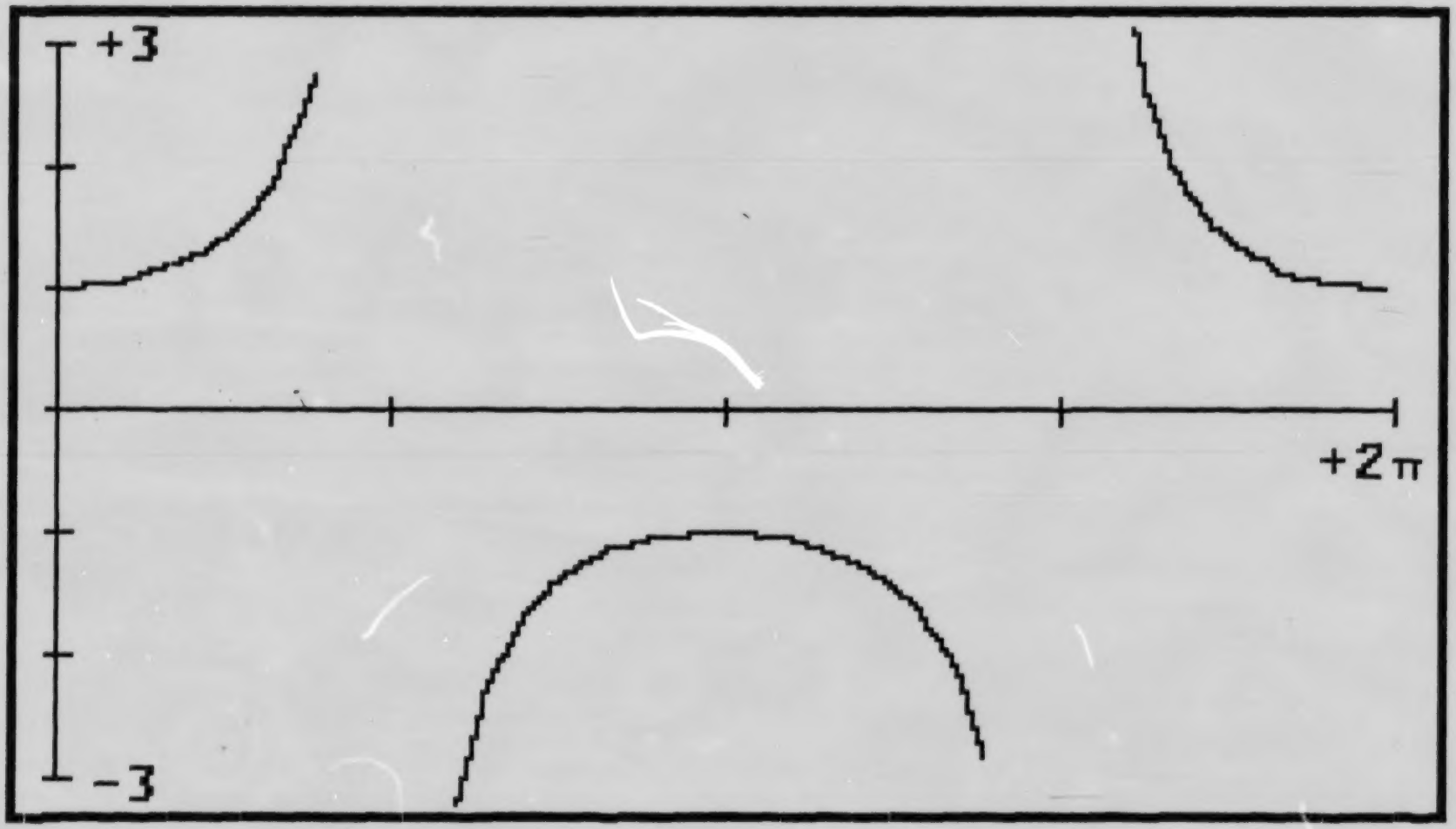
THIS IS A DEMONSTRATION OF THE CAPABILITIES OF THE TRIGONOMETRIC GRAPHING PROGRAMS. SEVERAL FUNCTIONS AND FAMILIES OF FUNCTIONS WILL BE GRAPHED.

TO VEIW A CONTINUOUS LOOP OF FUNCTIONS AND THEIR GRAPHS PRESS THE SPACE BAR.



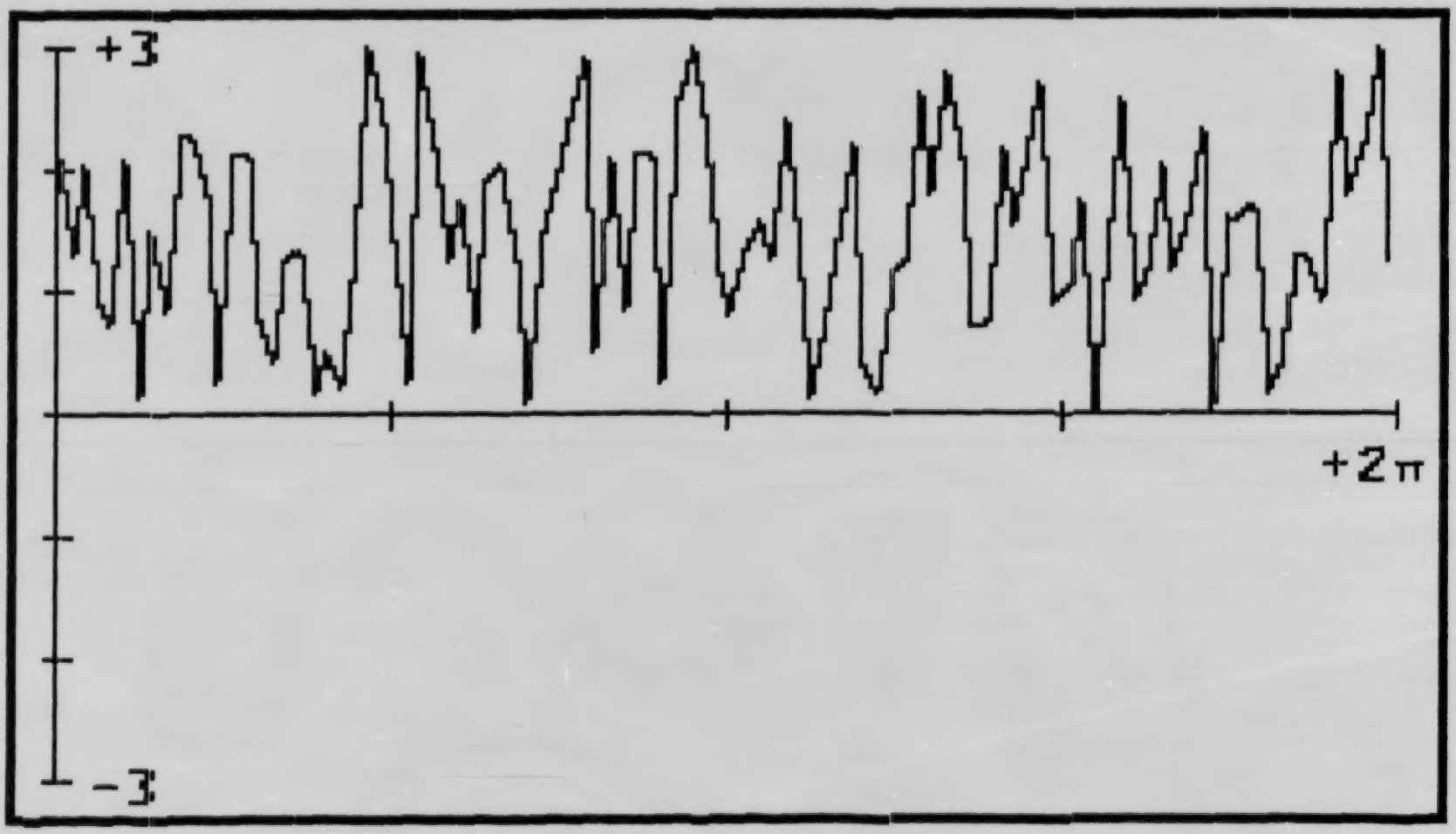
FUNCTION: F(X)=3*SIN(X)

>>> PRESS SPACE BAR TO CONTINUE <<<



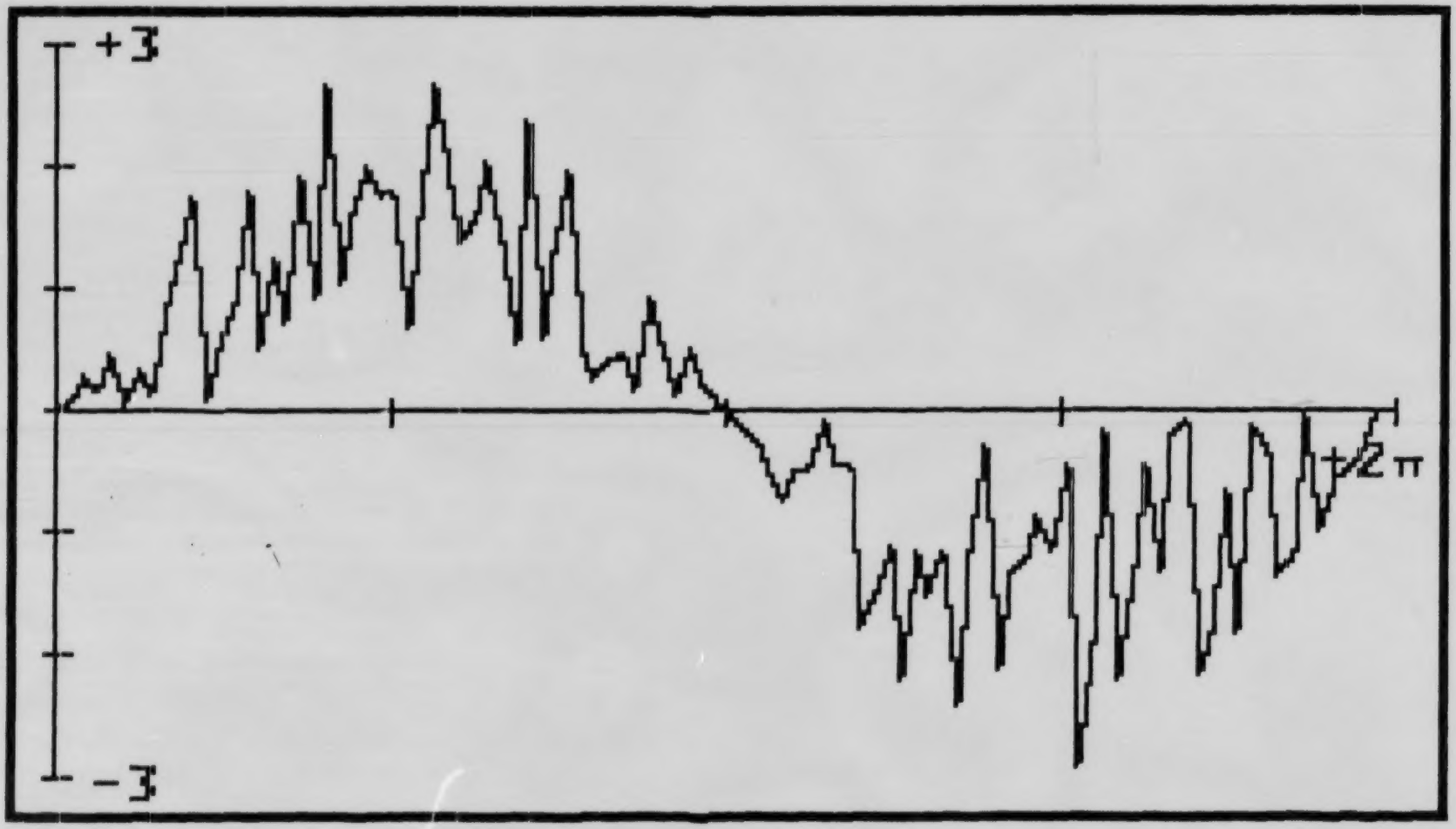
FUNCTION: F(X)=1/COS(X)

>>> PRESS SPACE BAR TO CONTINUE <<<



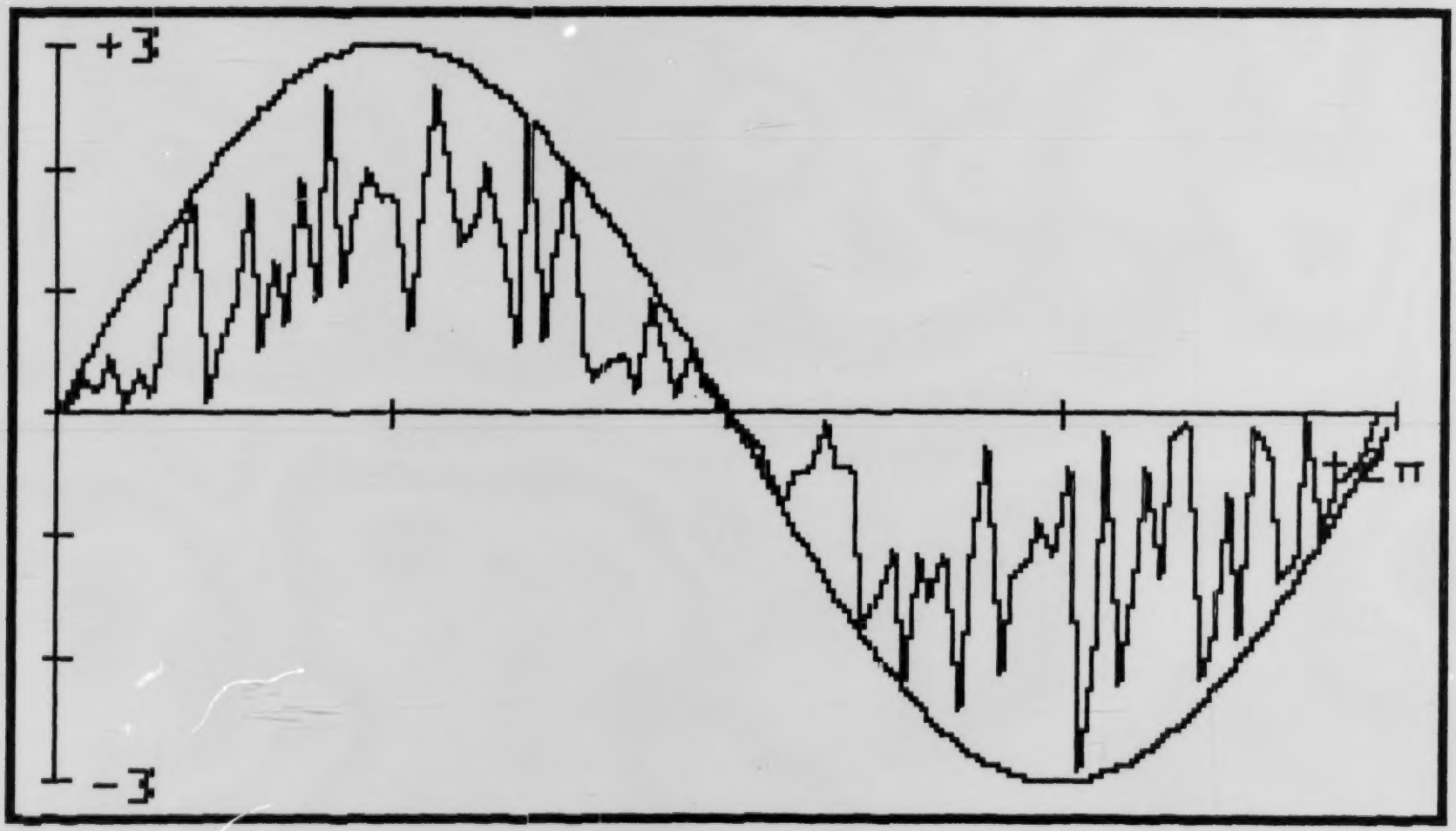
FUNCTION: F(X)=RND(1)*3

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=3*SIN(X)*RND(1)

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=3*SIN(X)*RND(1)

FUNCTION: F(X)=3*SIN(X)

>>> PRESS SPACE BAR TO CONTINUE <<<

GENERAL
TRIGONOMETRY
GRAPHING
PROGRAM

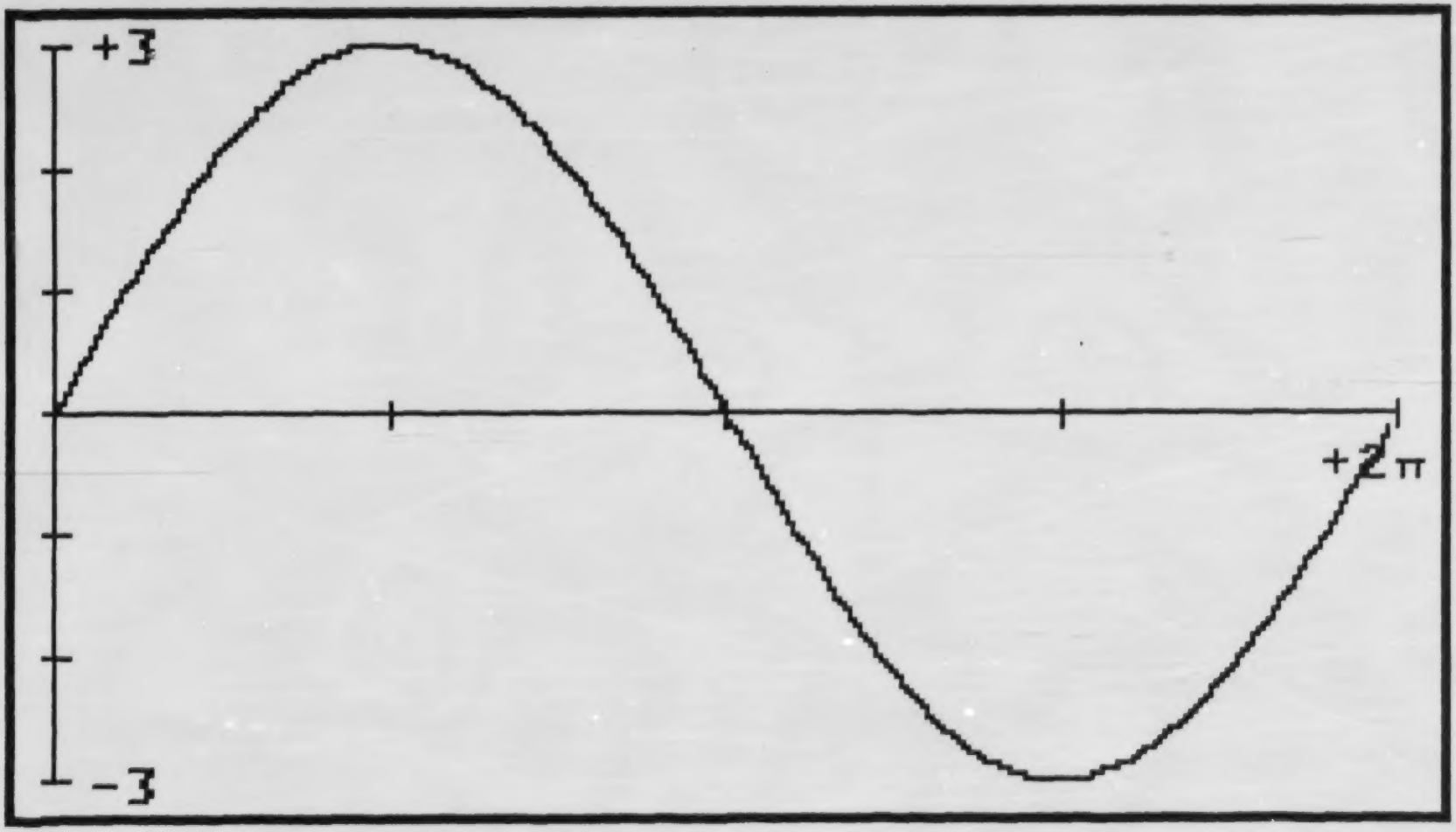
DO YOU NEED INSTRUCTIONS (Y OR N) ?


```
**********************************
* F(X): DEPENDENT VARIABLE       *
* X:    INDEPENDENT VARIABLE     *
* PI:   PI=3.1415927             *
**********************************
```

ALL FUNCTIONS MUST BE ENTERED IN BASIC NOTATION. PRESS THE RETURN KEY WHEN YOU HAVE FINISHED TYPING YOUR FUNCTION.

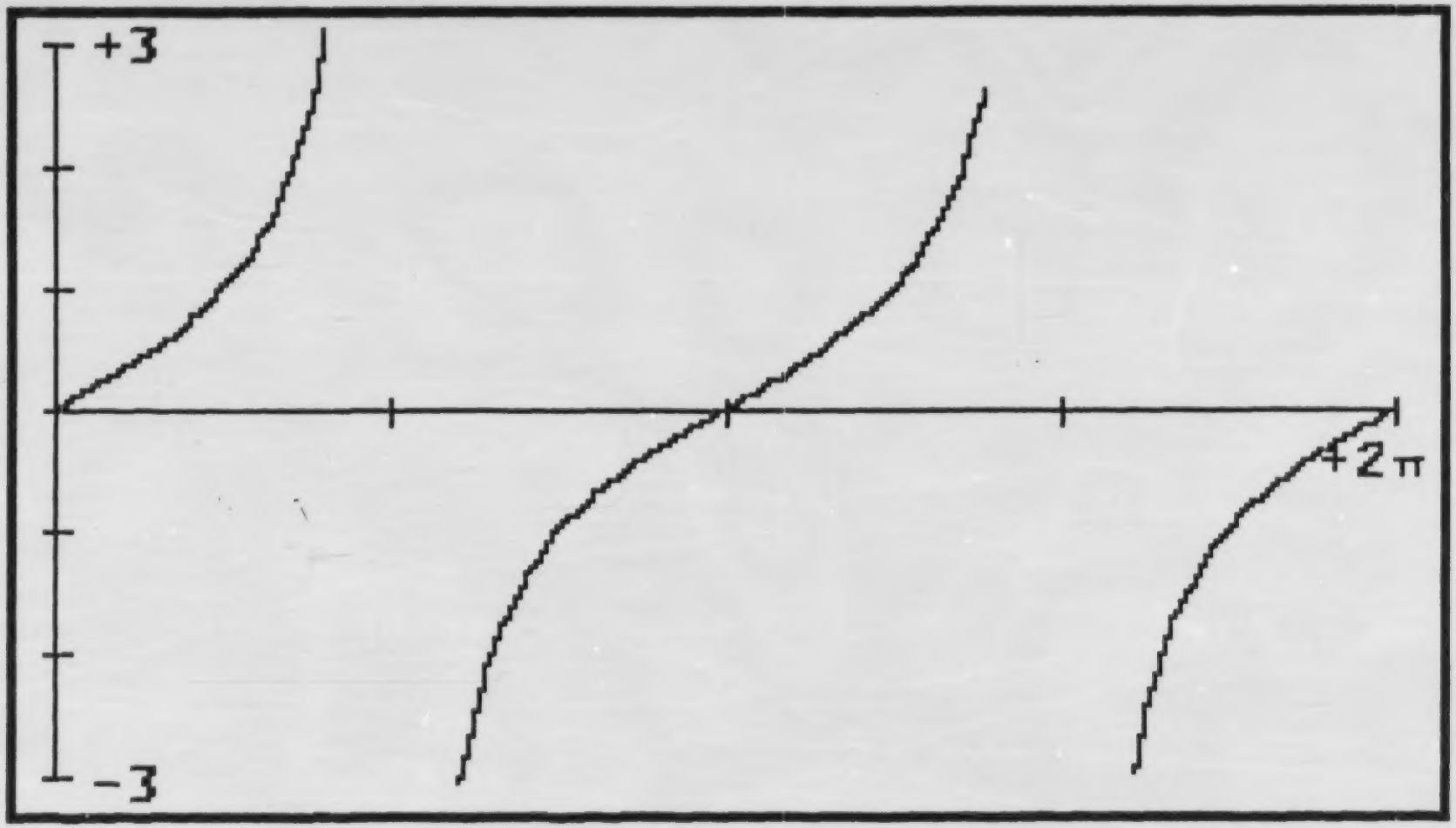
>>> ENTER YOUR TRIG. FUNCTION BELOW <<<

F(X) = 3 * SIN (X)



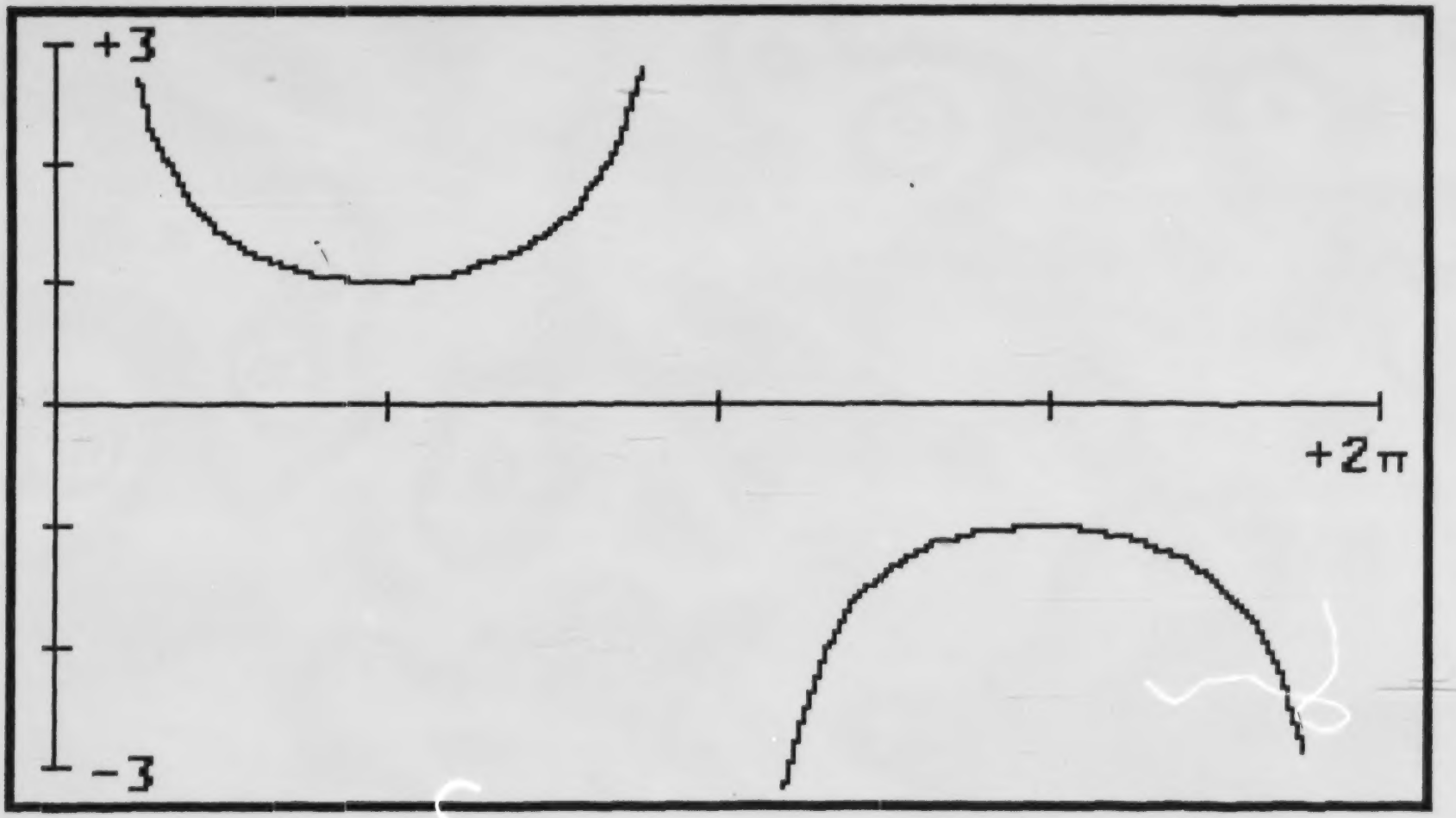
FUNCTION: F(X)=3*SIN(X)

>>> PRESS SPACE BAR TO CONTINUE <<<



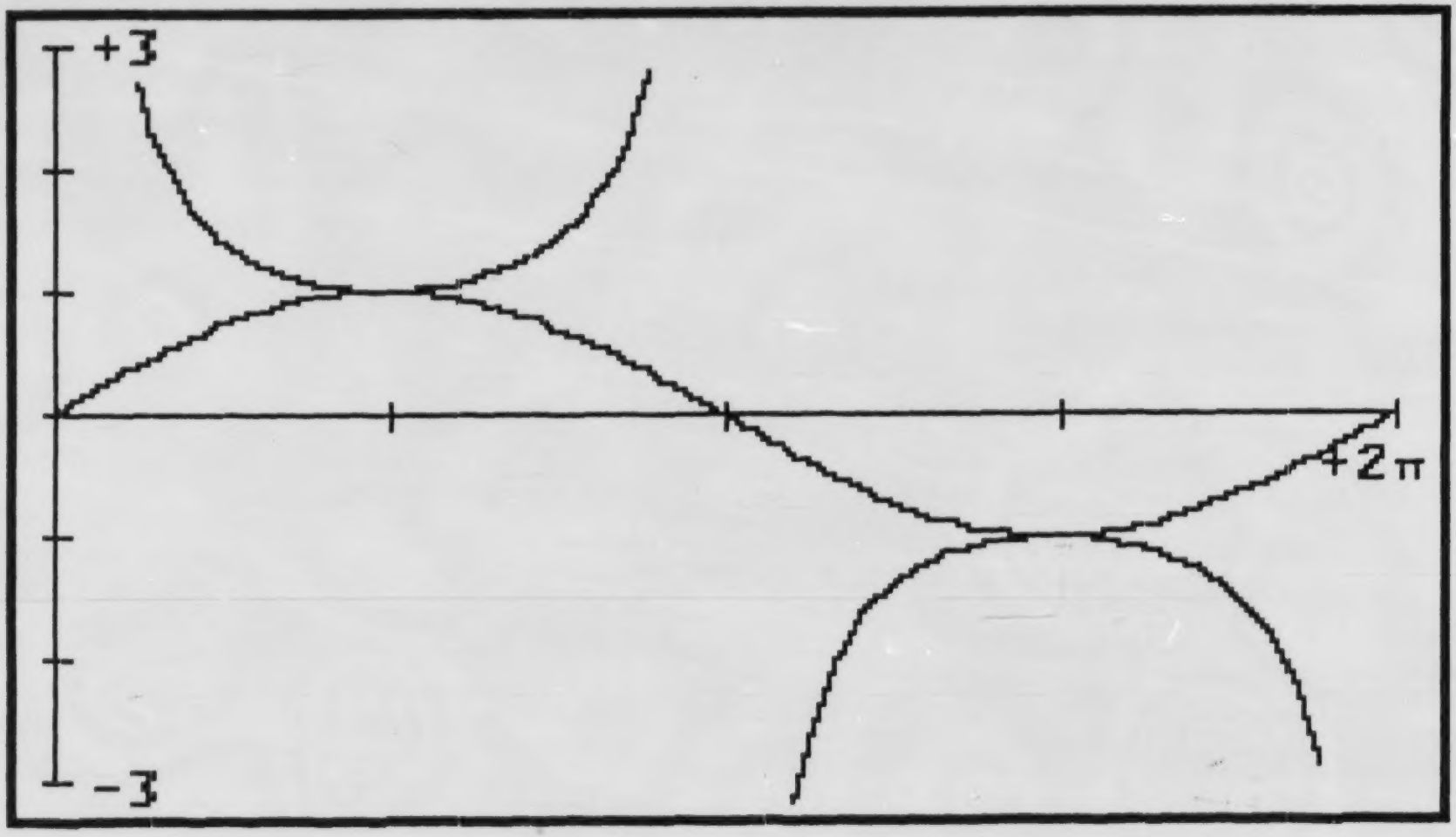
FUNCTION: F(X)=TAN(X)

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=1/SIN(X)

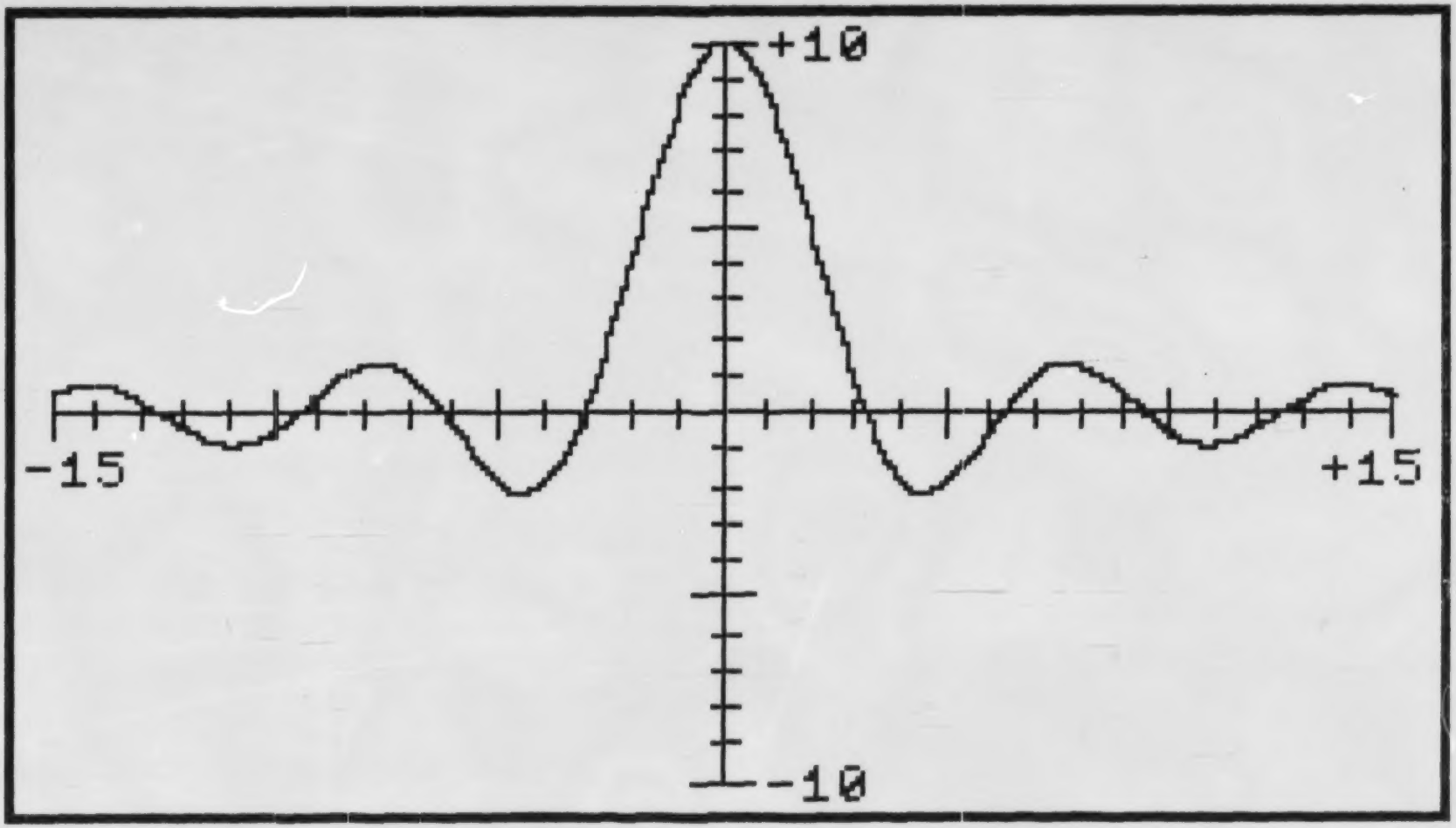
>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=1/SIN(X)

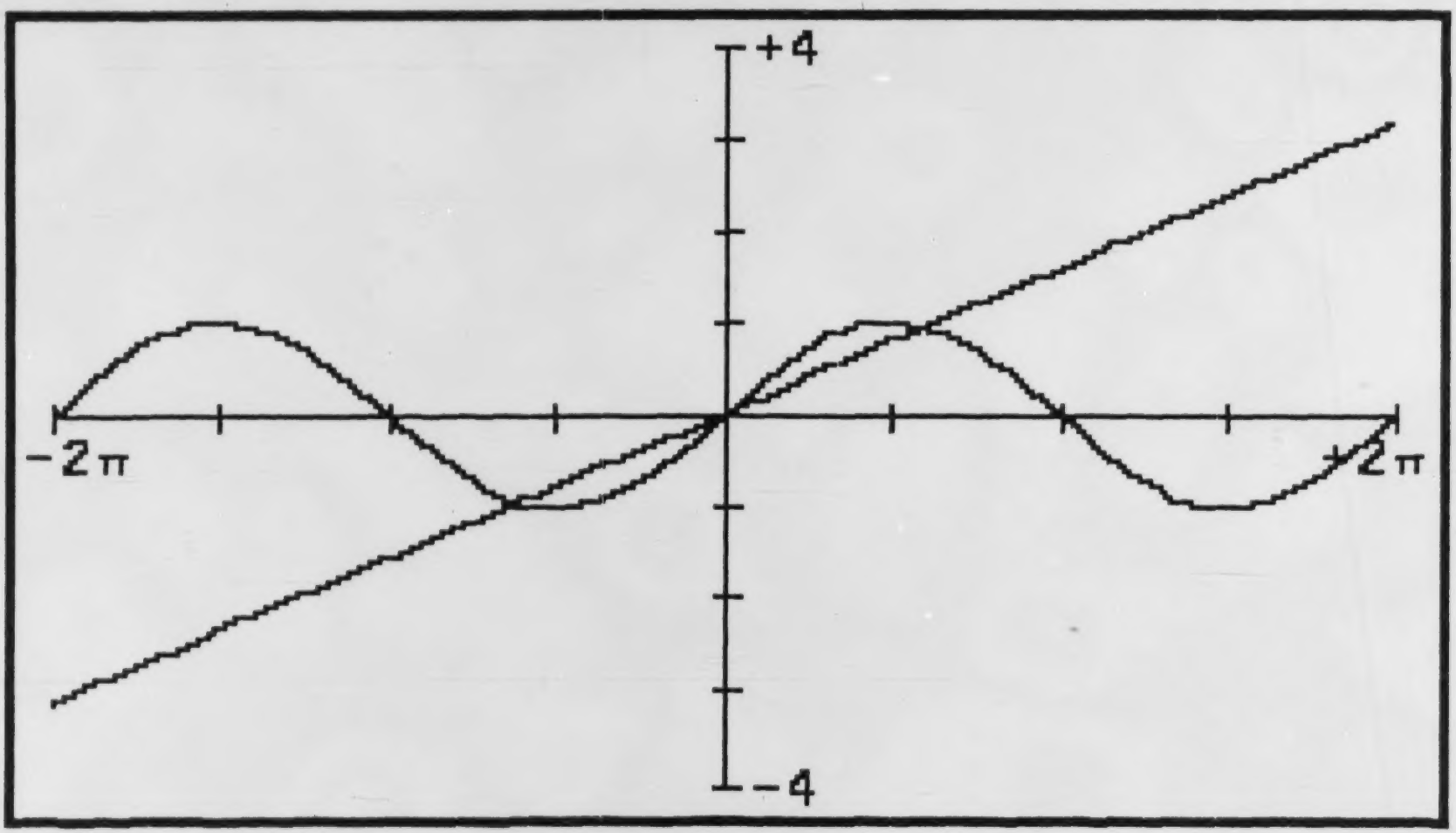
FUNCTION: F(X)=SIN(X)

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=10*SIN(X)/X

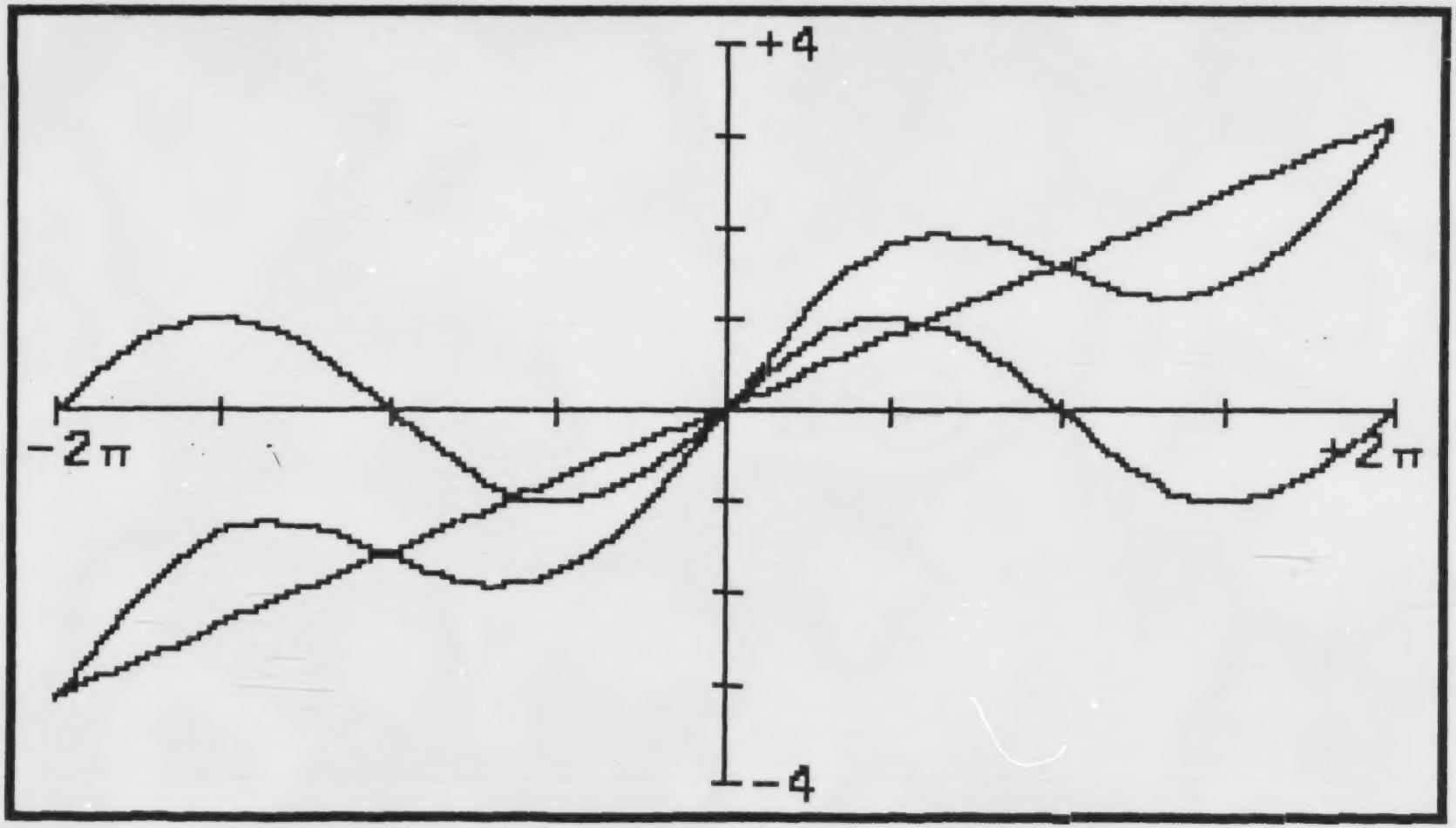
>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=SIN(X)

FUNCTION: F(X)=X/2

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=SIN(X)+X/2

FUNCTION: F(X)=SIN(X)

FUNCTION: F(X)=X/2

>>> PRESS SPACE BAR TO CONTINUE <<<

TRIGONOMETRY
TREND
PROGRAM

DO YOU NEED INSTRUCTIONS (Y OR N) ?

THIS PROGRAM GRAPHS A FAMILY OF THREE TRIGONOMETRIC FUNCTIONS WHEN YOU INCLUDE THE CONSTANT 'C' IN YOUR FUNCTION. THE CONSTANT 'C' TAKES ON THE VALUES 1 (WHITE GRAPH), 2 (BLUE GRAPH), AND 3 (GREEN GRAPH).
>>> PRESS SPACE BAR TO CONTINUE <<<

```
**************************************
* F(X):  DEPENDENT VARIABLE          *
* X:     INDEPENDENT VARIABLE        *
* C:     CONSTANT (C=1, 2, 3)        *
* PI:    PI=3.1415927                *
**************************************
```

ALL FUNCTIONS MUST BE ENTERED IN BASIC NOTATION. PRESS THE RETURN KEY WHEN YOU HAVE FINISHED TYPING YOUR FUNCTION.

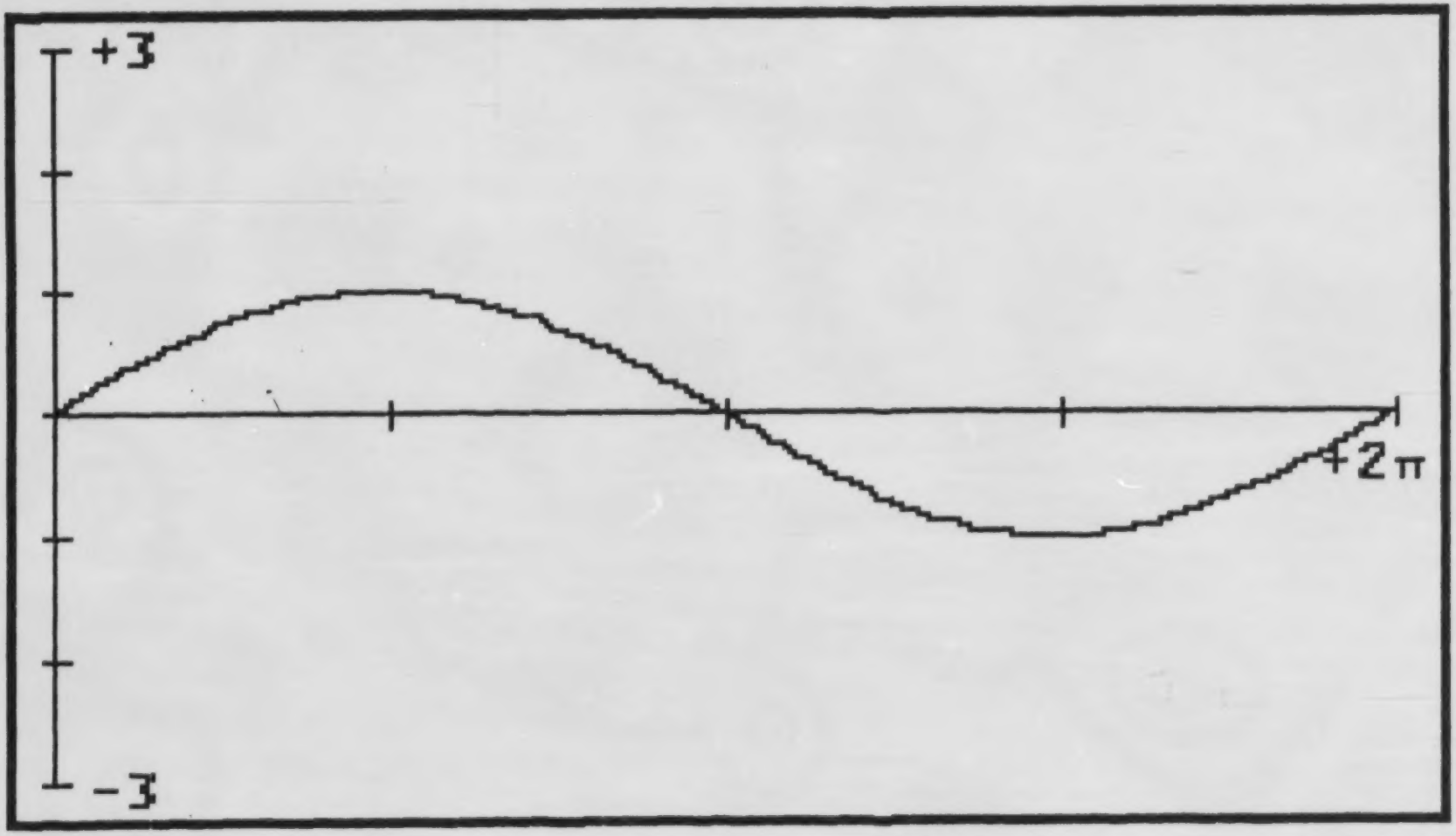
>>> ENTER YOUR TRIG. FUNCTION BELOW <<<

F(X) = C * SIN (X)

YOU MAY CHOOSE ANY OF THE FOLLOWING GRID SIZES:

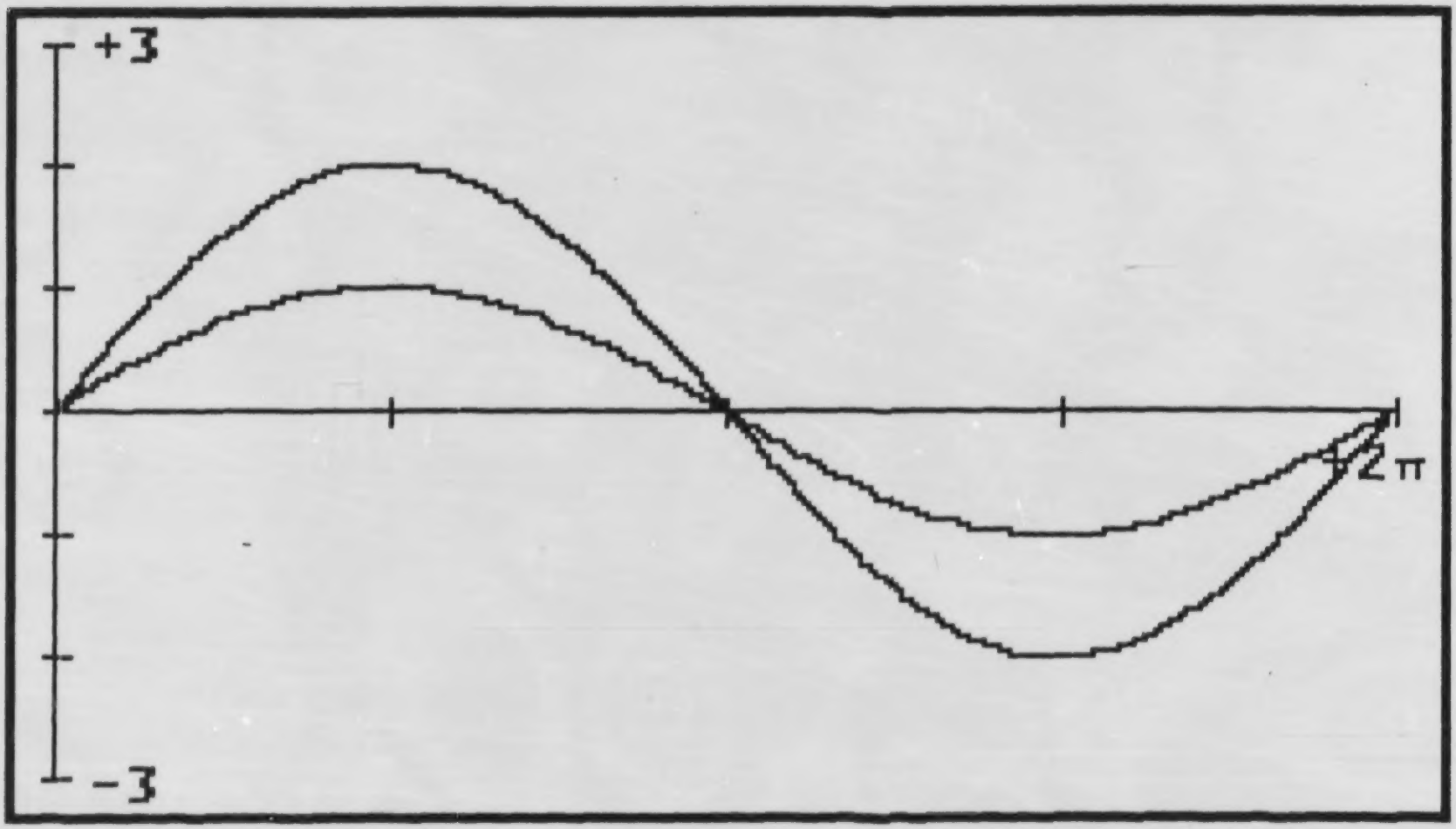
1. SMALL (X BETWEEN 0 AND 2 PI, Y BETWEEN -3 AND +3)
2. MEDIUM (X BETWEEN -2 PI AND +2 PI, Y BETWEEN -4 AND +4)
3. LARGE (X BETWEEN -15 AND +15, Y BETWEEN -10 AND +10)

SELECT THE GRID SIZE YOU WOULD LIKE TO USE (1, 2 OR 3) ?



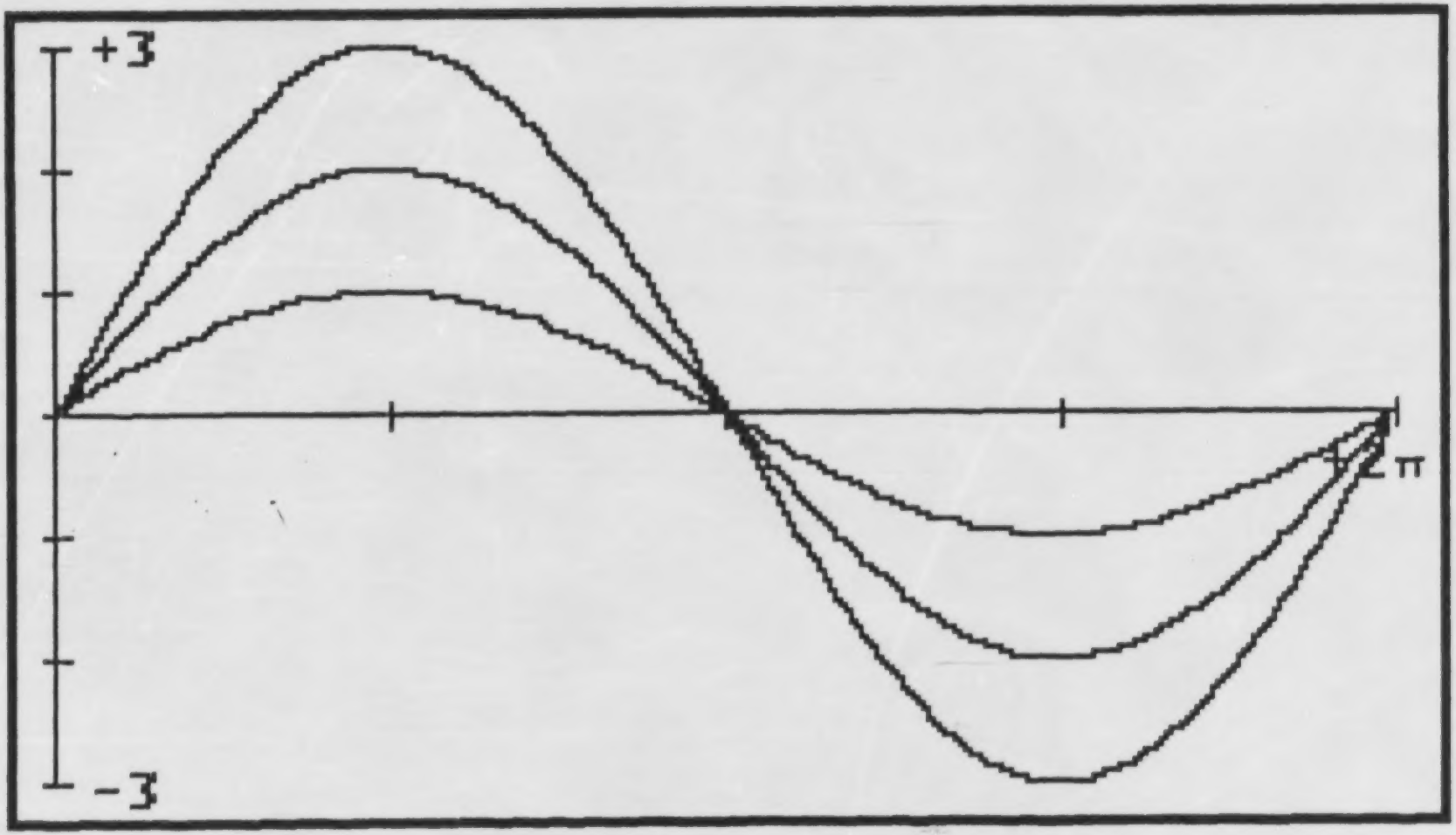
FUNCTION: F(X)=C*SIN(X) CONSTANT C=1

>>> PRESS SPACE BAR TO CONTINUE <<<



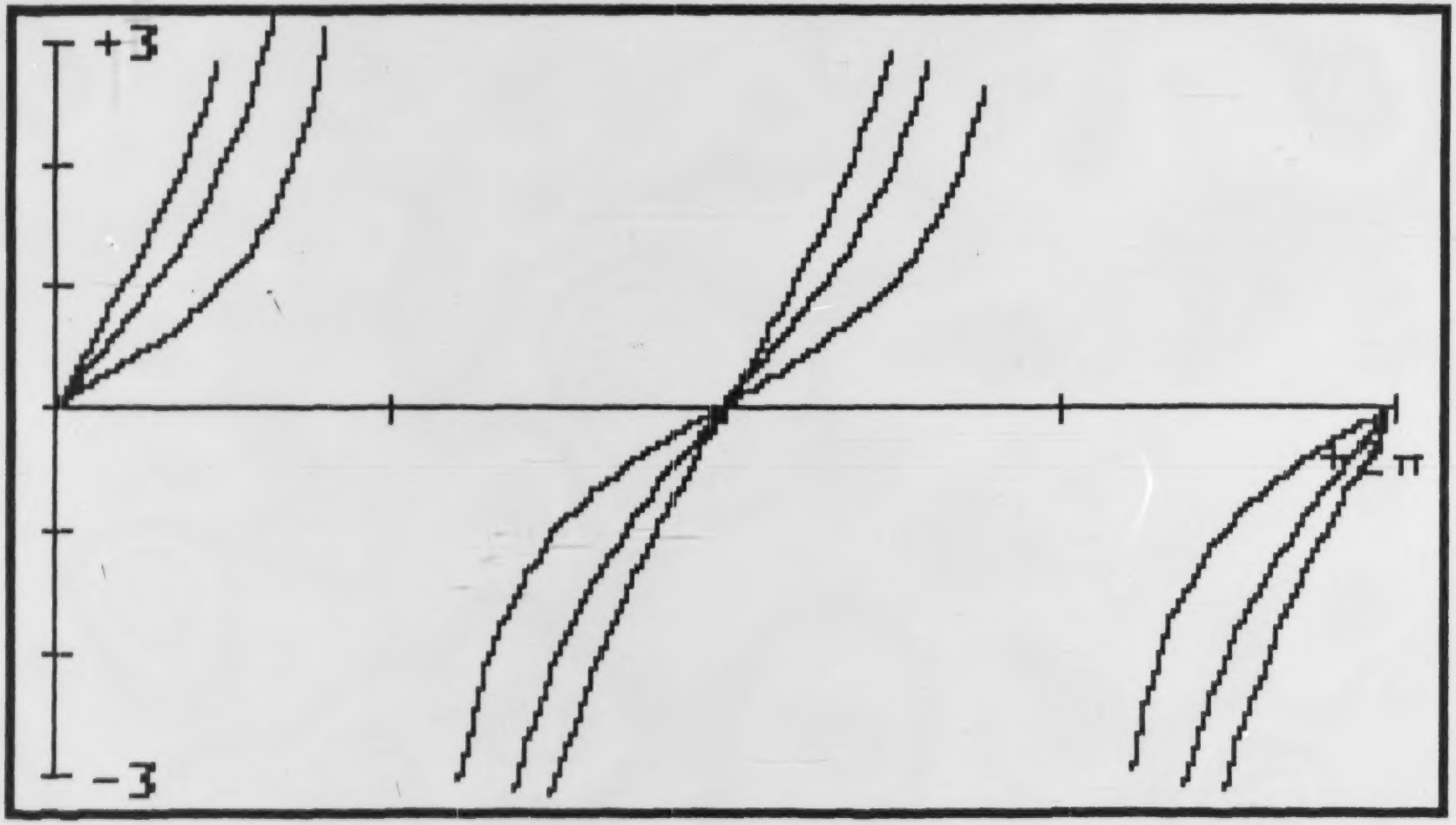
FUNCTION: F(X)=C*SIN(X) CONSTANT C=1, 2

>>> PRESS SPACE BAR TO CONTINUE <<<



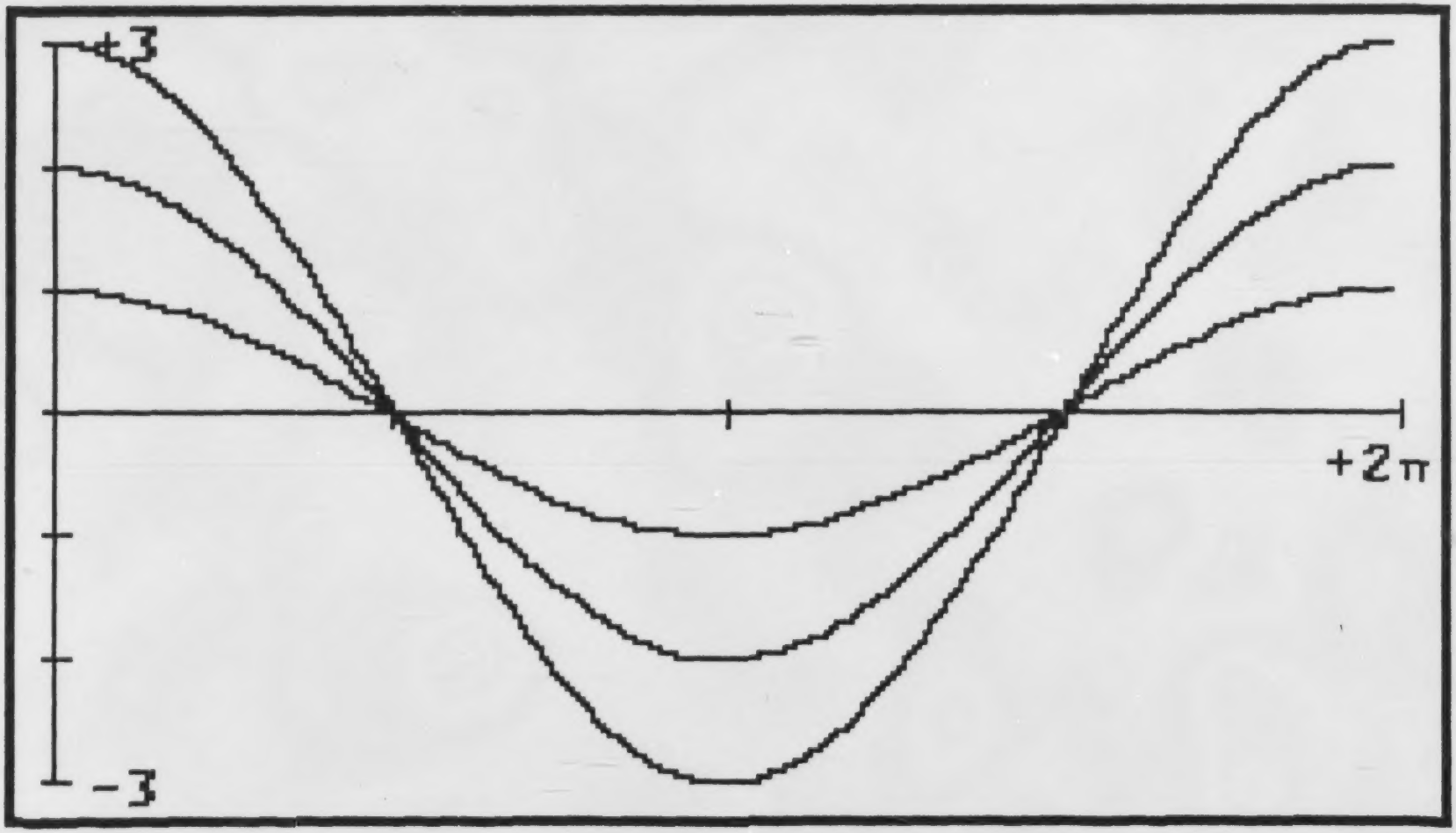
FUNCTION: F(X)=C*SIN(X) CONSTANT C=1, 2, 3

>>> PRESS SPACE BAR TO CONTINUE <<<



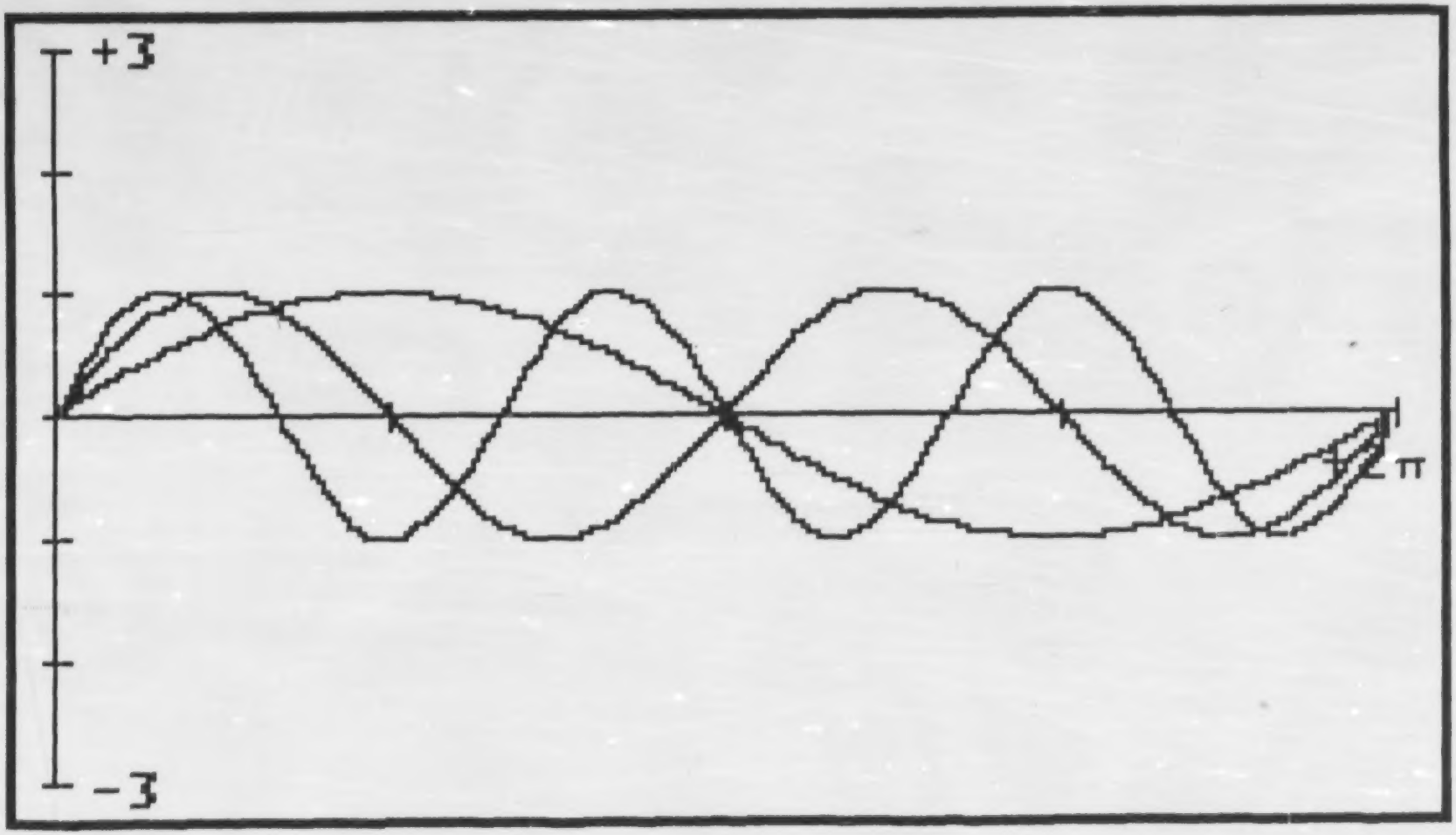
FUNCTION: F(X)=C*TAN(X) CONSTANT C=1, 2, 3

>>> PRESS SPACE BAR TO CONTINUE <<<



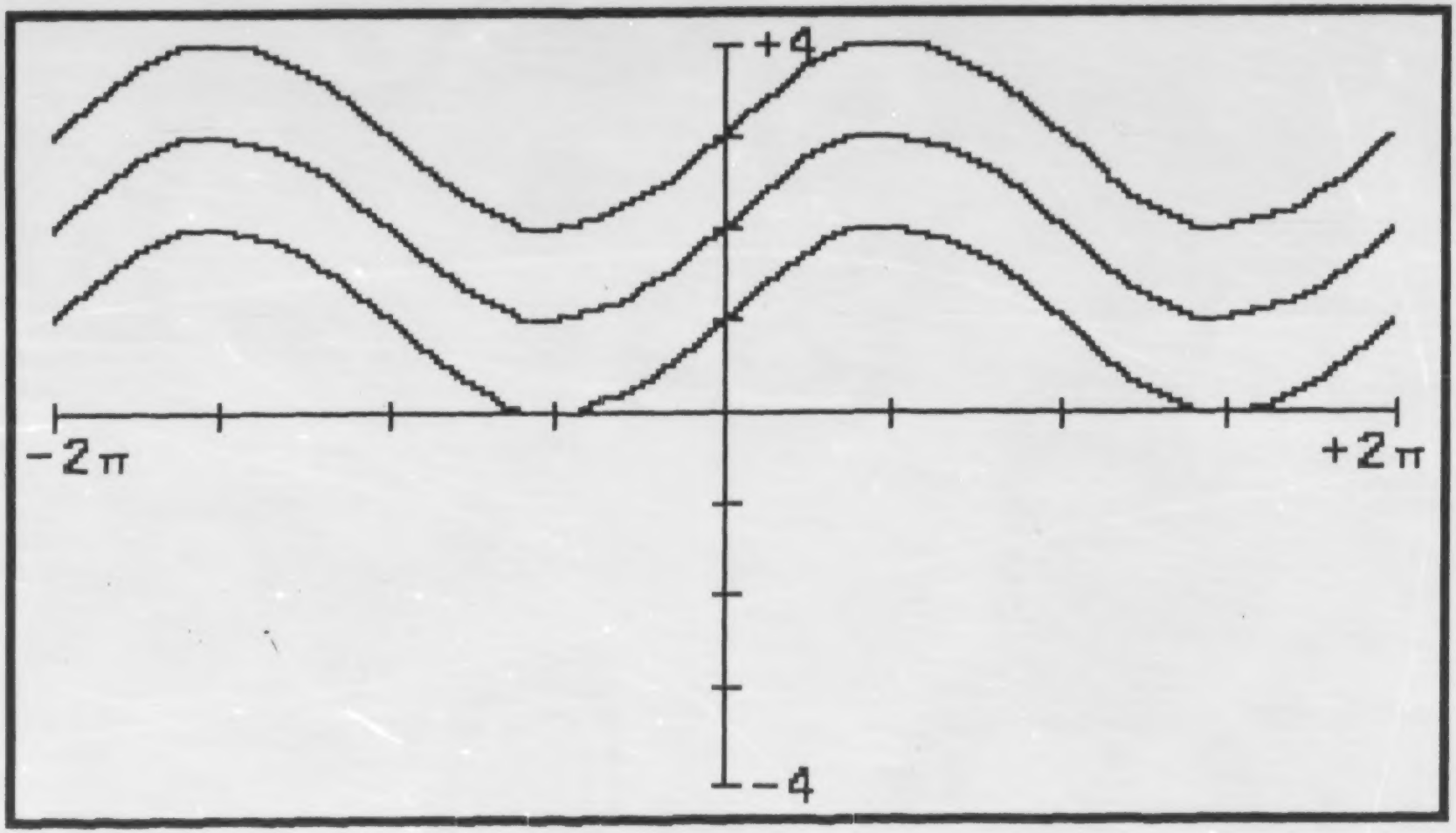
FUNCTION: F(X)=C*COS(X) CONSTANT C=1, 2, 3

>>> PRESS SPACE BAR TO CONTINUE <<<



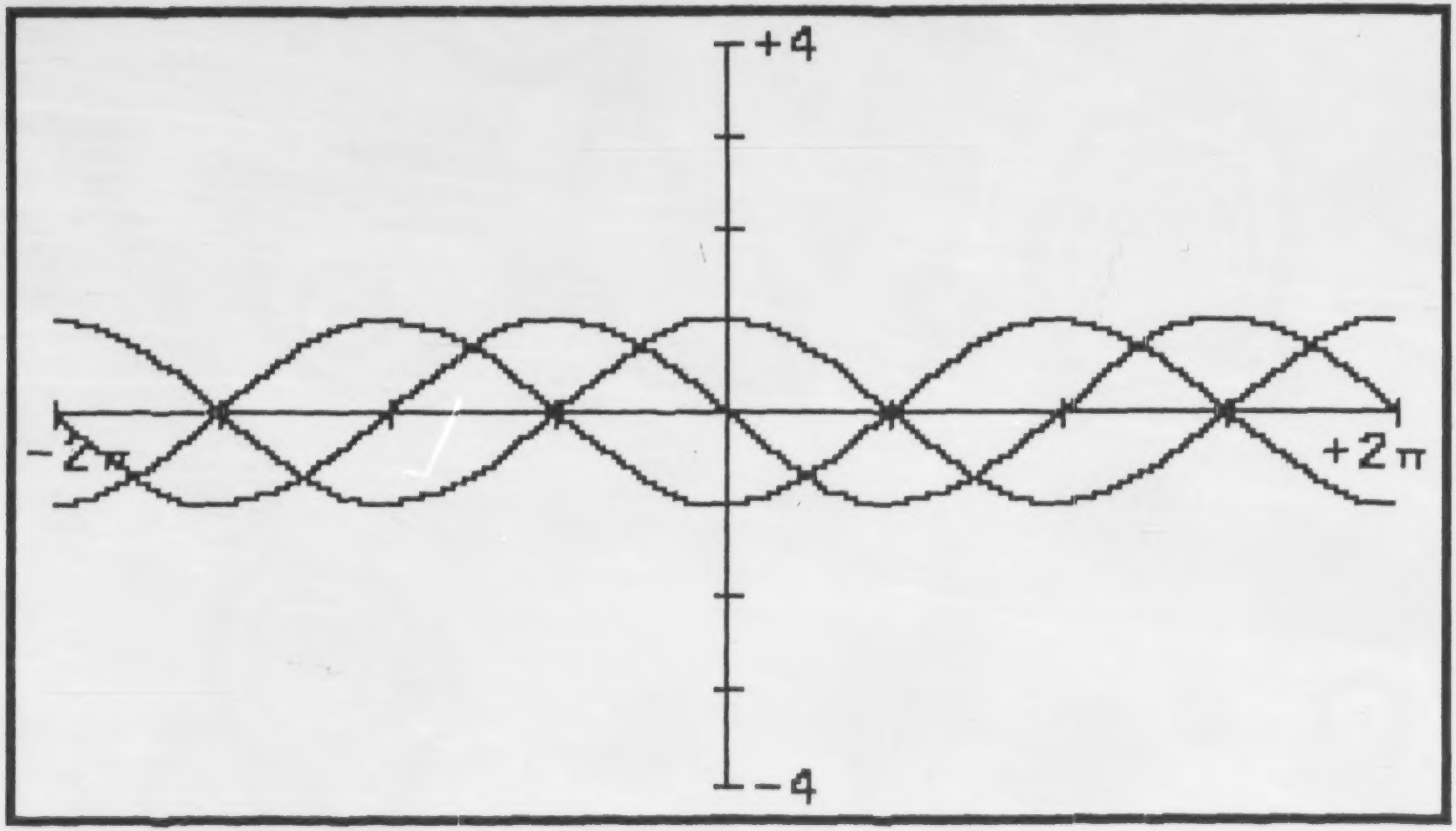
FUNCTION: F(X)=SIN(C*X) CONSTANT C=1, 2, 3

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=SIN(X)+C CONSTANT C=1, 2, 3

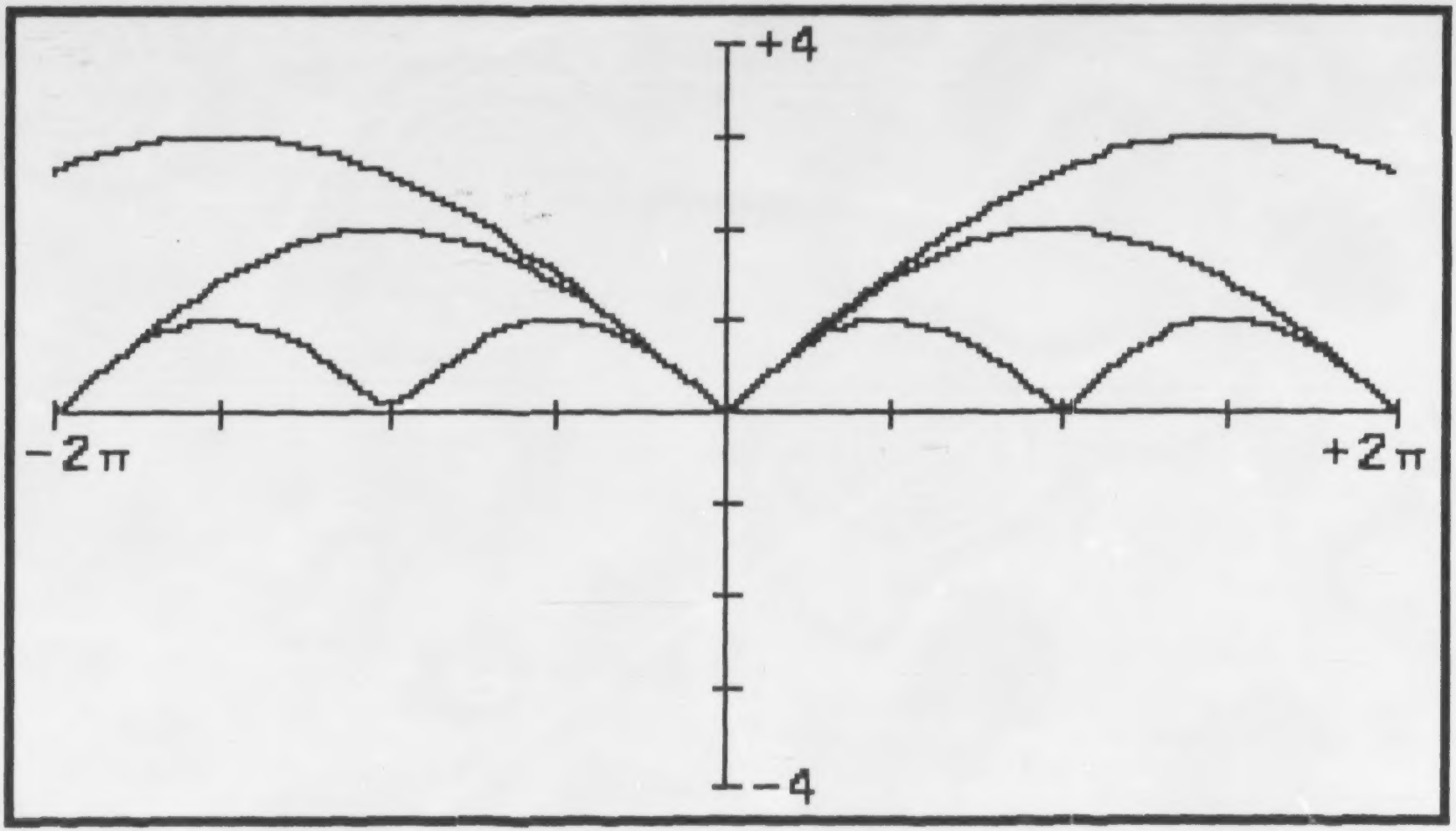
>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=SIN(X+C*PI/2)

CONSTANT C=1, 2, 3

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: F(X)=C*ABS(SIN(X/C))

CONSTANT C=1, 2, 3

>>> PRESS SPACE BAR TO CONTINUE <<<

PROBLEM SOVLING GRAPHICS PROGRAM
- TRIGONOMETRY -

BY JOHN C. KELLY, PH. D.

DO YOU NEED INSTUCTIONS?Y

INSTRUCTIONS:
THIS PROGRAM RANDOMLY SELECTS A FUNCTION AND PLOTS THE GRAPH ON THE THE SCREEN. YOUR PROBLEM IS TO IDENT-IFY THE EQUATION OF THE GRAPH. YOU MAY HAVE AS MANY GUESSES AS YOU WISH. THE COMPUTER WILL GRAPH YOUR GUESS AND TELL YOU WHETHER YOUR EQUATION IS CORRECT.

-PRESS THE SPACE BAR TO CONTINUE -

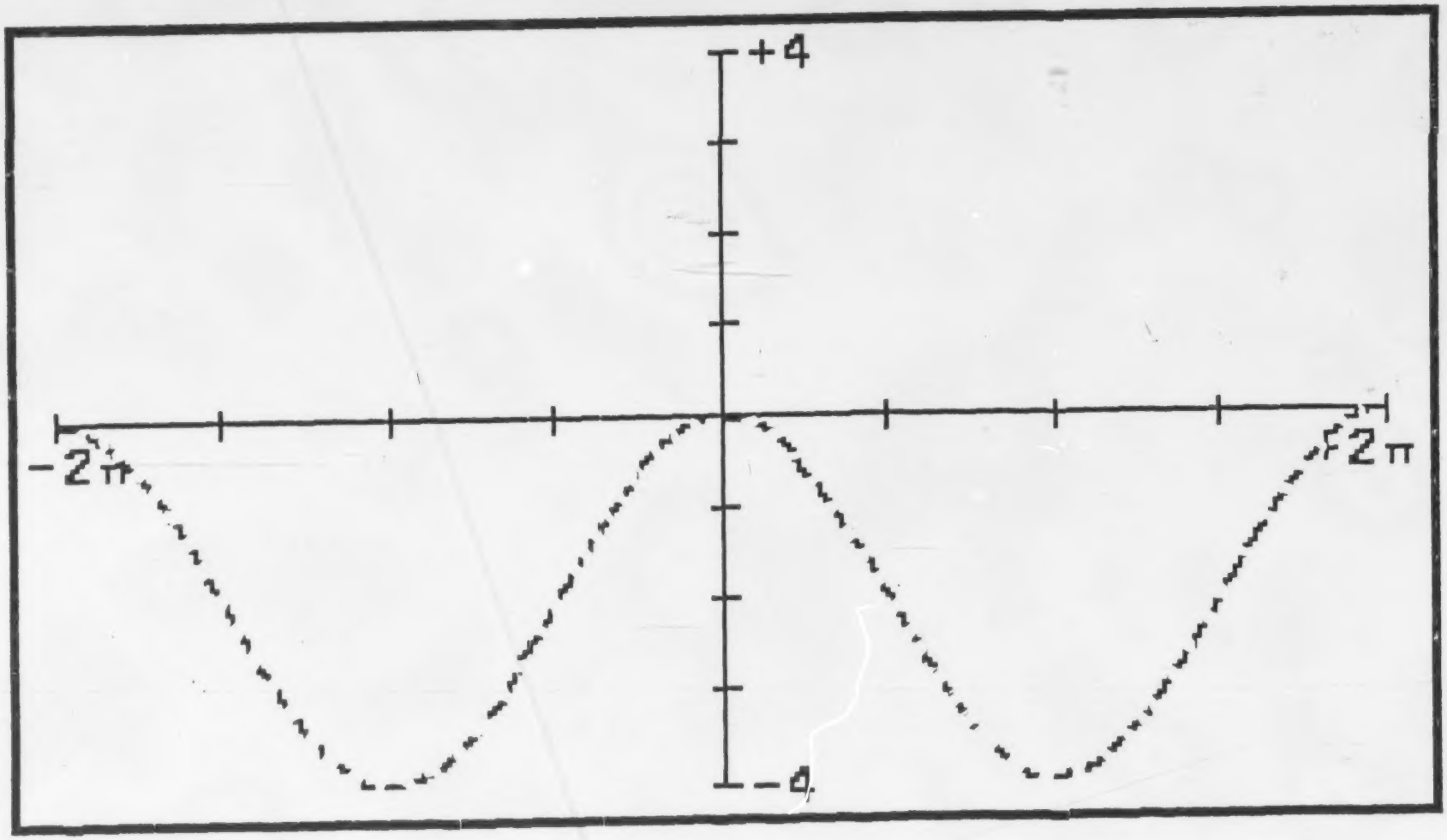
LEVELS OF PROBLEM SOLVING:

1. SIN & COS FUNCTIONS ONLY.
2. SIN, COS, TAN, SEC*, CSC*, & COT* FUNCTIONS.
3. SIN, COS, TAN, SEC*, CSC*, & COT* FUNCTIONS WITH PHASE SHIFT.
4. SAME AS 1 EXCEPT GRAPH IS DRAWN BY A MOVING POINT.
5. SAME AS 2 EXCEPT...
6. SAME AS 3 EXCEPT...

* NOTE THAT SEC, CSC, & COT MUST BE ENTERED IN THEIR RECIPROCAL FORM OF 1/COS(X), 1/SIN(X), & 1/TAN(X).

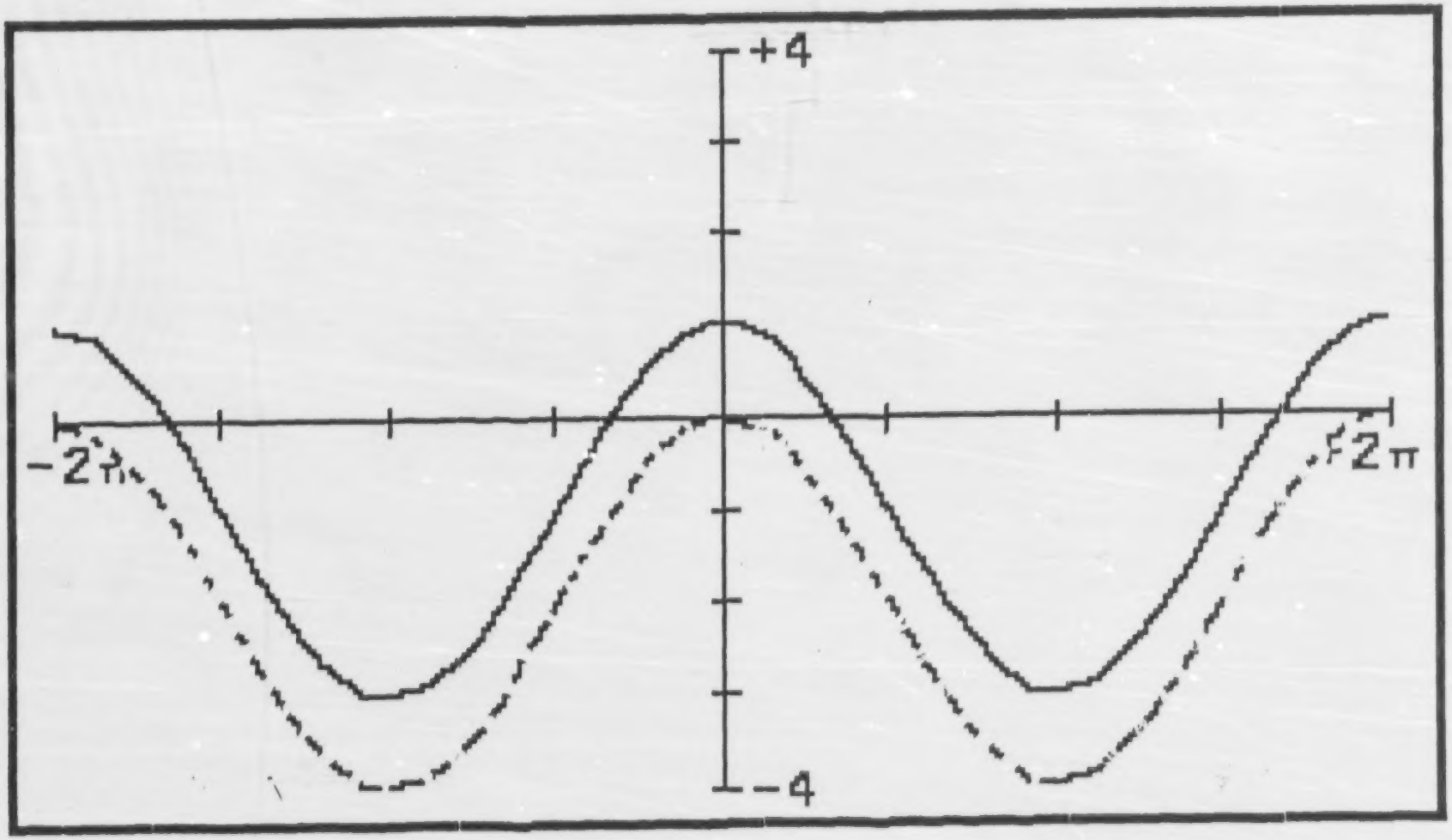
-PRESS THE SPACE BAR TO BEGIN -

ROUNDS COMPLETED:0
ROUNDS SOLVED:0
CHOOSE THE LEVEL OF DIFFICULTY
(INPUT A NUMBER FROM 1 TO 6)
?1



ENTER YOUR FUNCTION (GUESS) BELOW

Y =

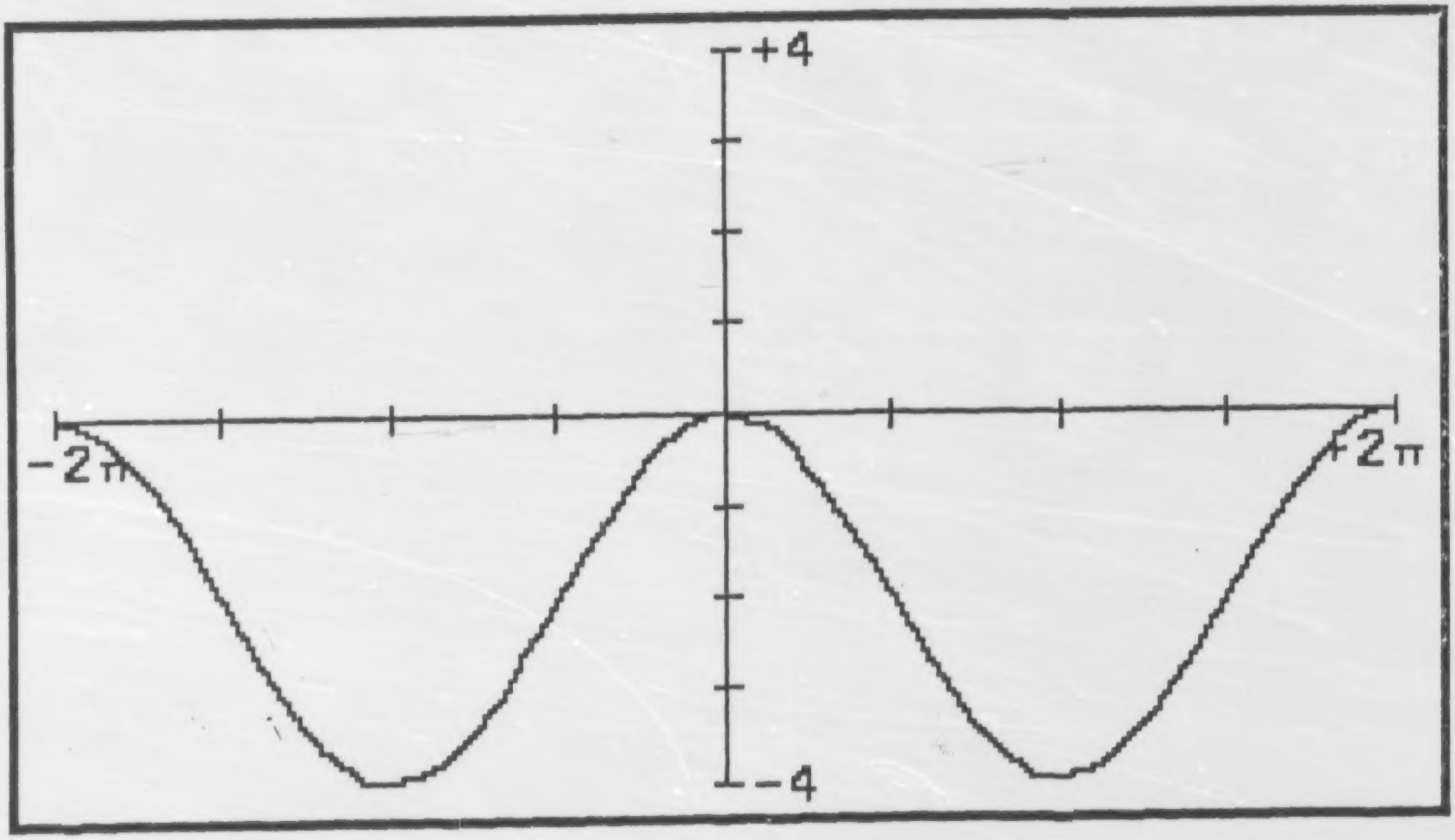


ENTER YOUR FUNCTION (GUESS) BELOW

Y=-2*COS(X)-1

INCORRECT

WOULD YOU LIKE TO TRY AGAIN?



ENTER YOUR FUNCTION (GUESS) BELOW

Y=-2*COS(X)-2

CORRECT!

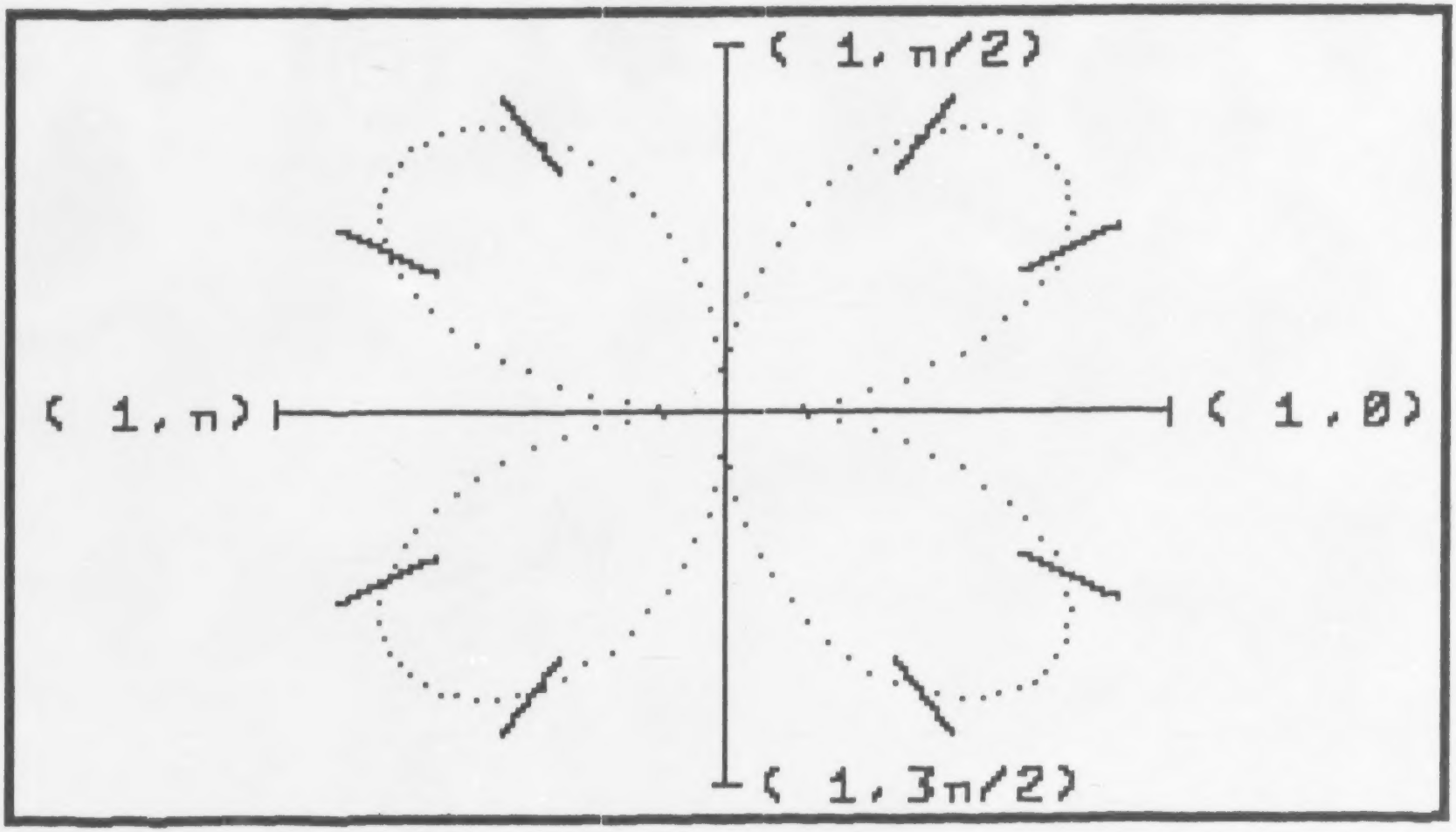
WOULD YOU LIKE TO TRY ANOTHER ROUND?

```
GENERAL POLAR PROGRAM

DO YOU NEED INSTRUCTIONS (Y OR N) ?
```



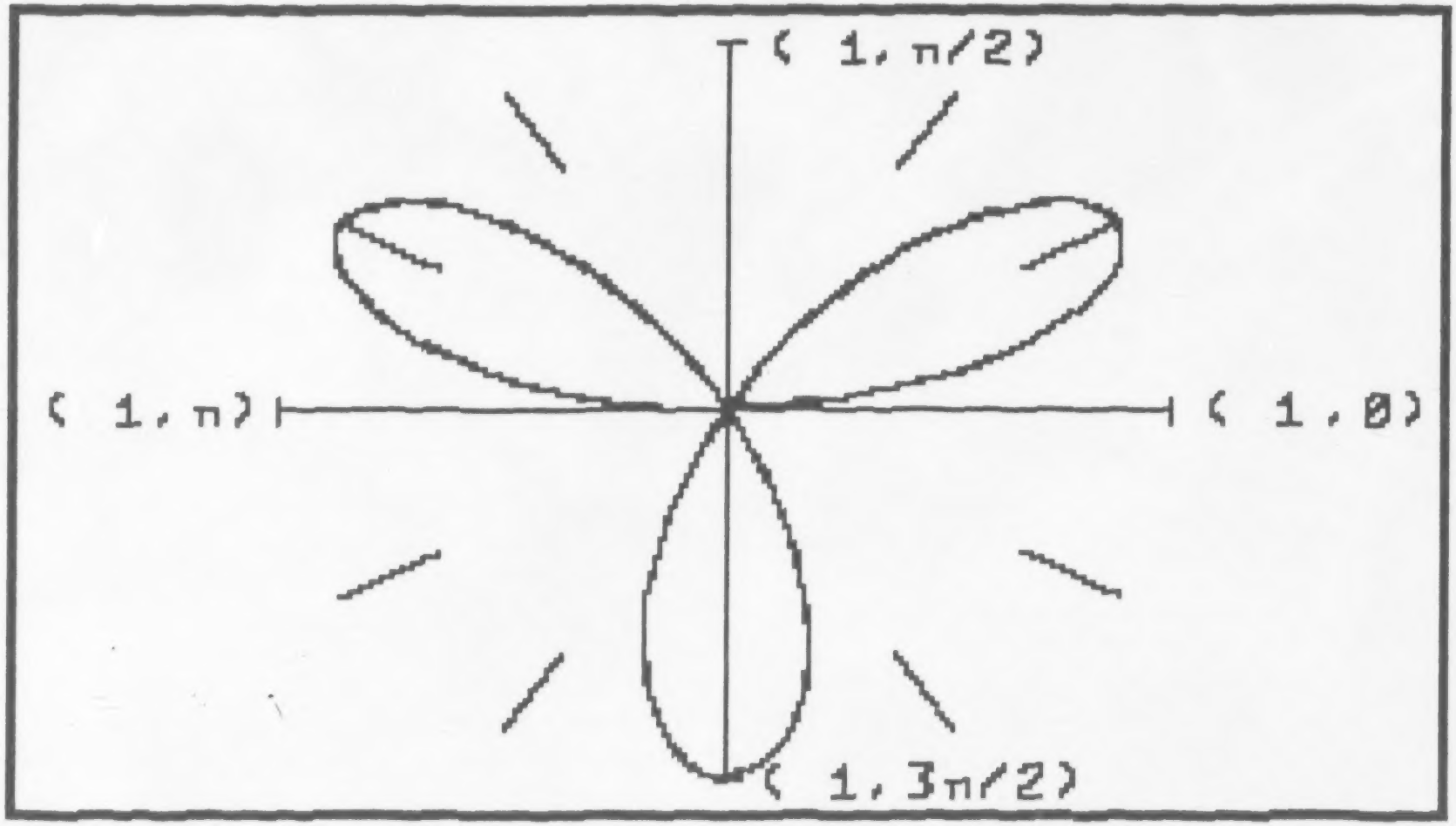
```
YOUR POLAR FUNCTIONS MUST BE
ENTERED IN APPLESOFT BASIC NOTATION.

VARIABLES
   R:RADIUS
   A:ANGLE (IN RADIANS)
CONSTANTS:
   PI=3.1415927
    E=2.7182818

>>> ENTER YOUR POLAR FUNCTION BELOW <<<

R(A) =  SIN (2 * A)
```

```
MAXIMUM RADIUS OF GRID (1 TO 99)?

PLOT DOTS OR LINES (D OR L) ?

DO YOU WANT TO SELECT THE COLORS OF
THE GRAPH (Y OR N) ?
```



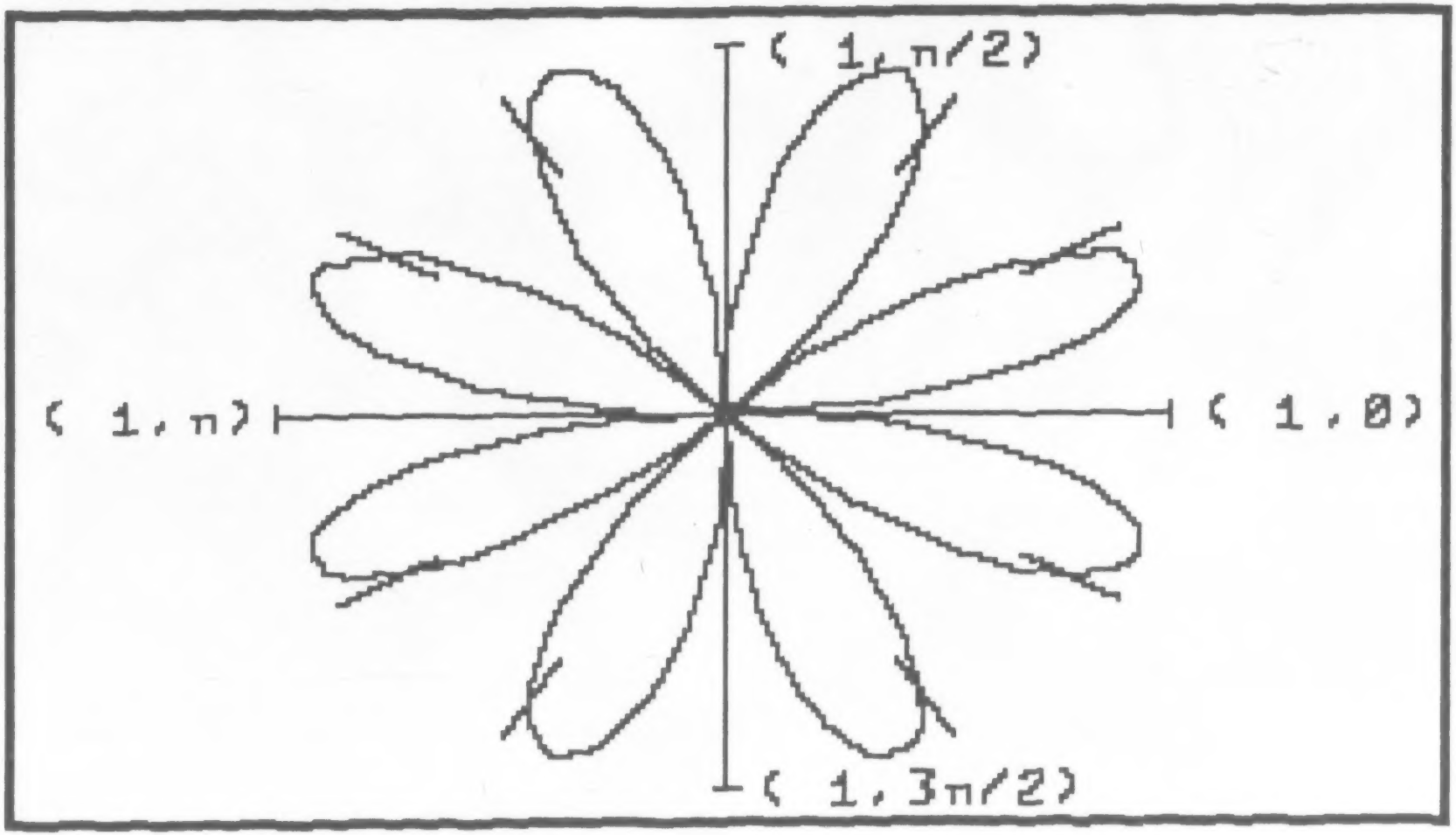
FUNCTION: R(A)=SIN(A*2)

>>> PRESS SPACE BAR TO CONTINUE <<<



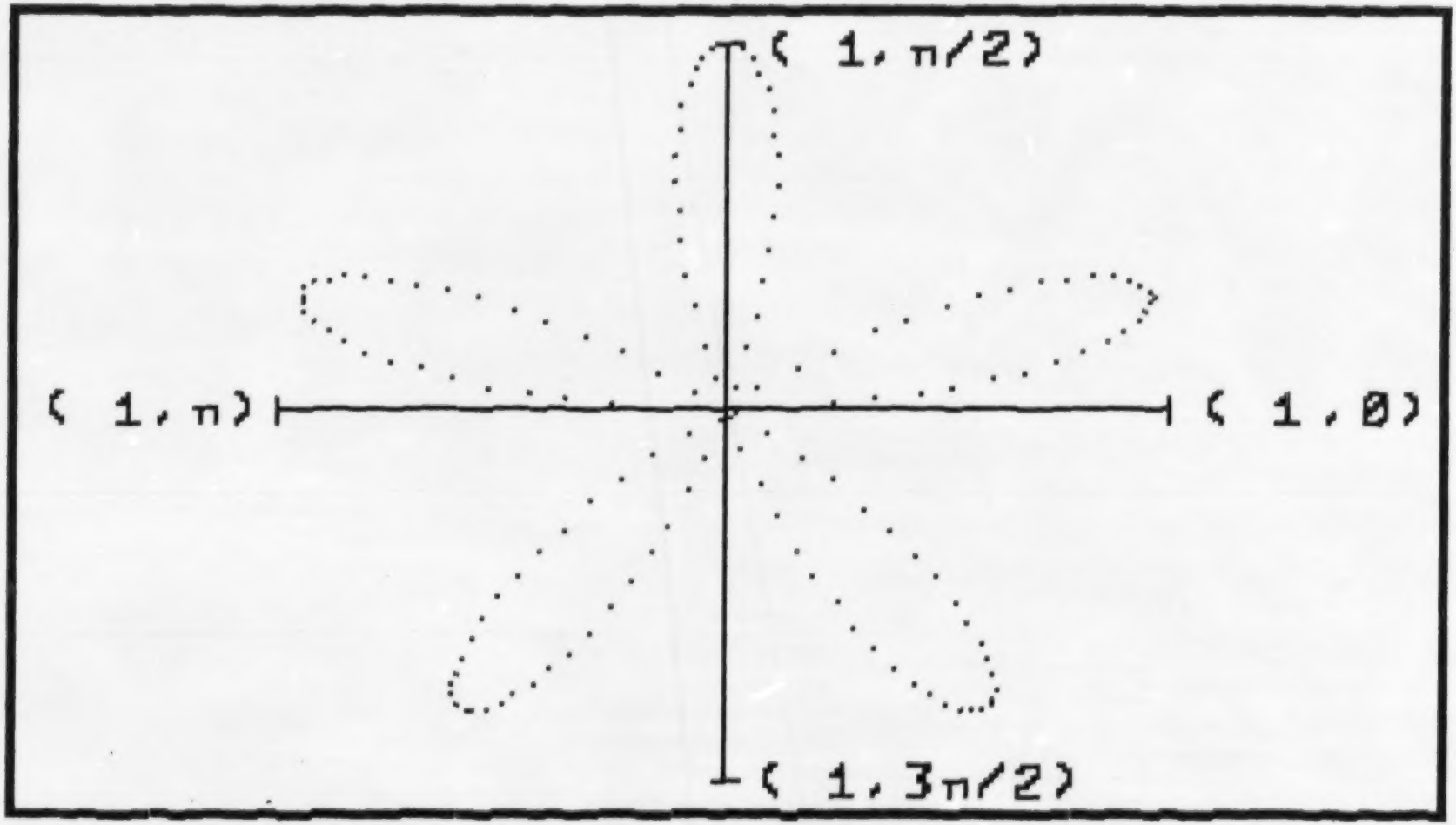
FUNCTION: R(A)=SIN(A*3)

>>> PRESS SPACE BAR TO CONTINUE <<<



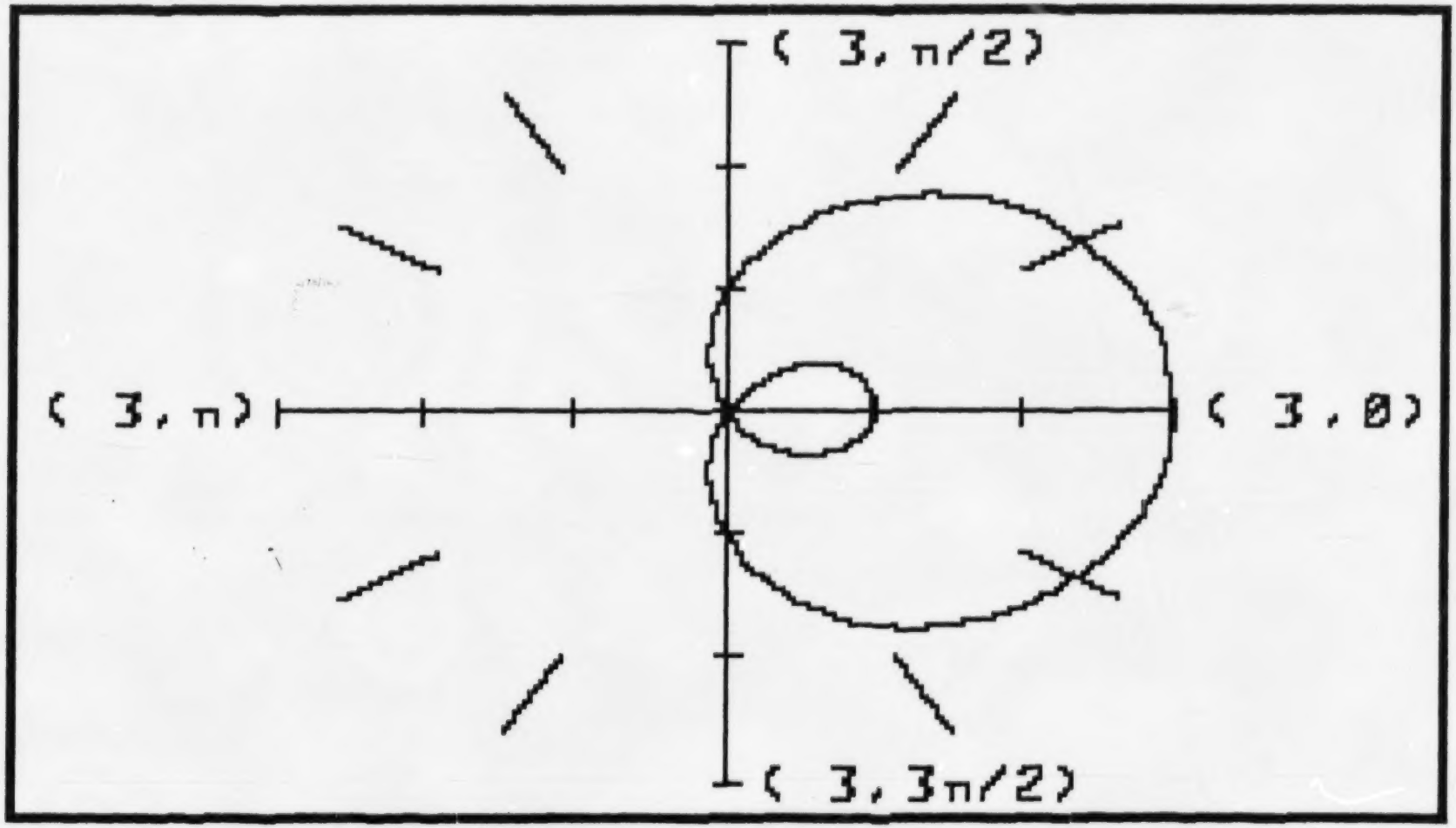
FUNCTION: R(A)=SIN(A*4)

>>> PRESS SPACE BAR TO CONTINUE <<<



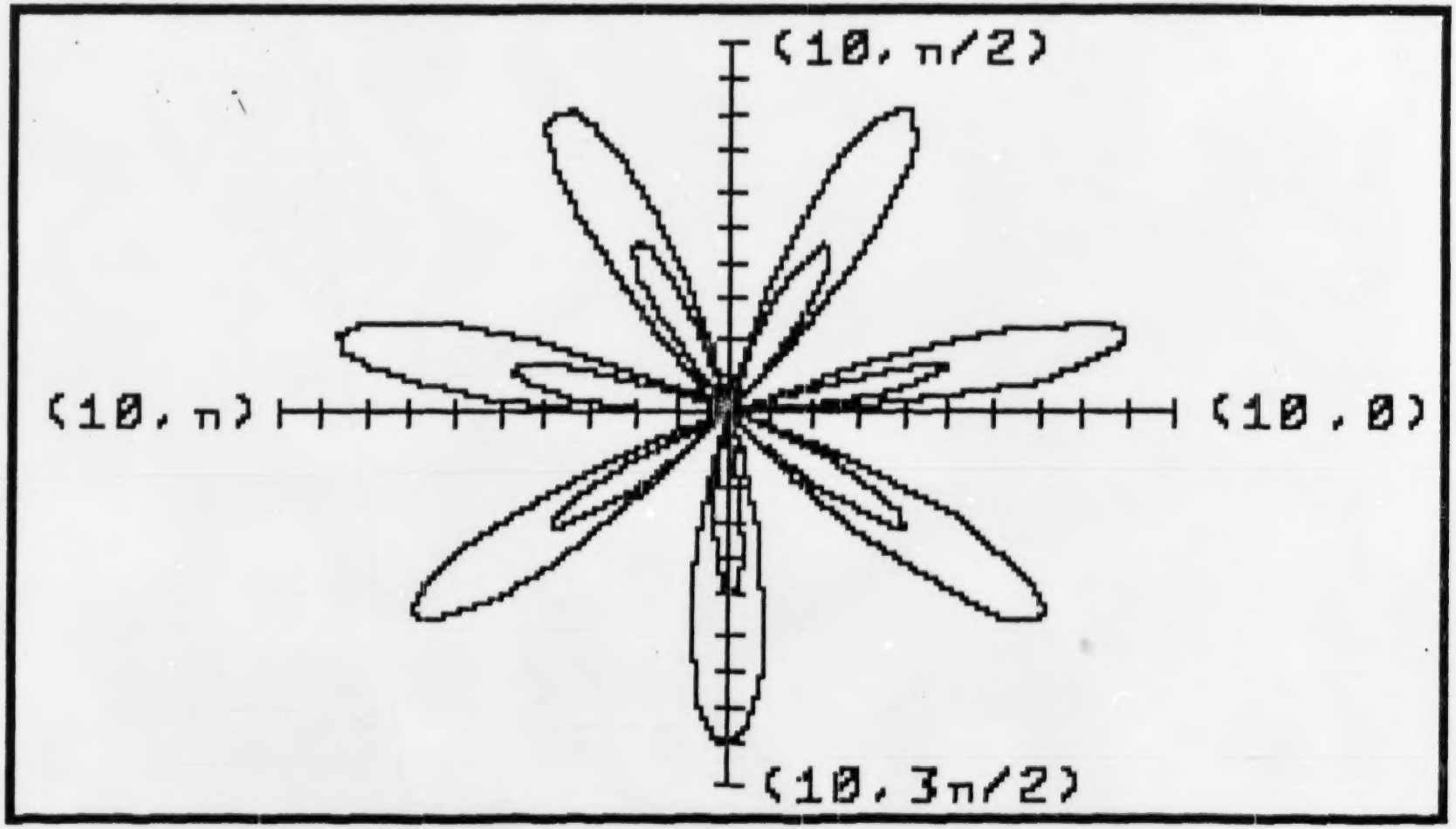
FUNCTION: R(A)=SIN(A*5)

>>> PRESS SPACE BAR TO CONTINUE <<<



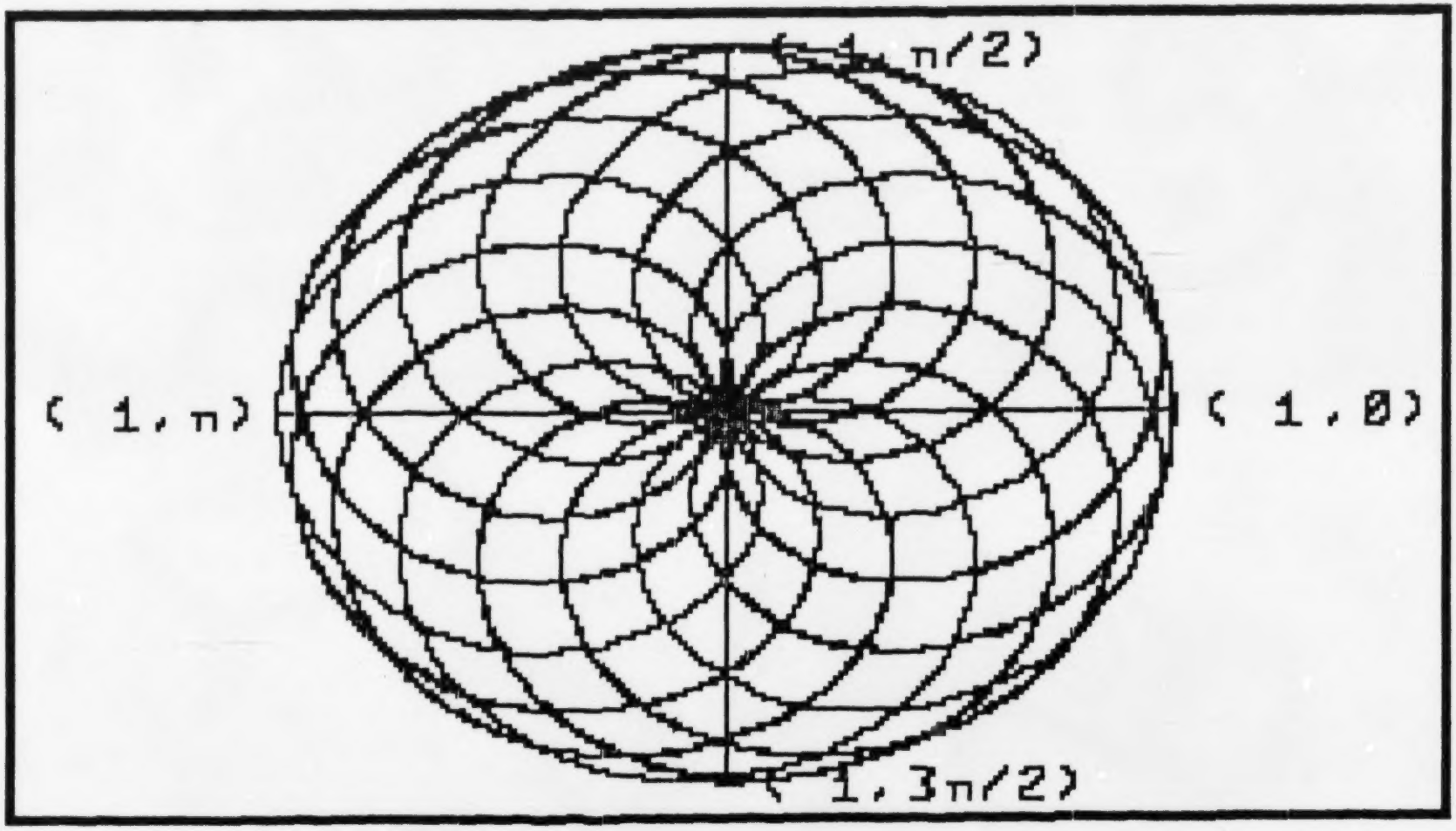
FUNCTION: R(A)=1+2*COS(A)

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: R(A)=SIN(A*7)*7-2

>>> PRESS SPACE BAR TO CONTINUE <<<



FUNCTION: R(A)=SIN(A*.7)

>>> PRESS SPACE BAR TO CONTINUE <<<

THE FOLLOWING ALBANY JUNIOR COLLEGE STUDENT ASSISTANTS CONTRIBUTED TO THE SUCCESS OF THE 'MATHEMATICAL GRAPHING COURSEWARE FOR MICROCOMPUTERS' PROJECT.

ROB BANDY
MARK FALLIS
TOM FOX
TERRI HAUBER
BOBBY MADDEN
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AND
JEFF WILLIAMS